5 .A2J

BER, 1926

URNAL

OF

NC ENTOM

Association of Economic

ZER FELT, *Editor*
TON, *Associate Editor*
, *Business Manager*

Advisory Committee
LAWSON CAESAR
ICKLIN SHERMAN, JR.

PUBLISHED BY
ION OF ECONOMIC EN
GENEVA, N. Y.

Entered as Second-class matter at the Post-Office at
Act of March 3, 1879

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGIST

VOL. 19 OCTOBER, 1926 No. 5

Proceedings of the Eleventh Annual Meeting of the Pacific Slope Branch American Association of Economic Entomologists

The 11th annual meeting of the Pacific Slope Branch, American Association Economic Entomologists was held June 17 and 18, 1926. Thursday's sessions were held at the University of California in Berkeley, Calif., and Friday's sessions at Mills College, in Oakland. The registered attendance exceeded that of any previous meeting.

The opening and closing sessions were devoted to business meetings, while the rest of the time was occupied by symposia and the presentations of papers. The symposium on oil sprays was the outstanding session of the meeting, both in attendance, interest in the papers, and discussions. After adjournment, the Federal and State Entomologists met in the 3rd annual Pacific Coast Championship baseball game. In order to remain victors, the State men quit in the 5th inning, while still one run ahead. The meetings closed with a well attended dinner Friday night.

PART I. BUSINESS PROCEEDINGS

The meeting was called to order at 9:15 A. M. by Chairman Herms. Seventy-four members and visitors attended the sessions. The following were present.

Browne, Ashley C., Sacramento, Calif.
Bruner, Lawrence, Berkeley, Calif.
Campbell, Roy E., Alhambra, Calif.
Cody, L. R., San Jose, Calif.
Currier, D. L., San Jose, Calif.
de Ong, E. R., Berkeley, Calif.
Doucette, Chas. F., Santa Cruz, Calif.
Doane, R. W., Stanford University, Cal.
Drake, Carl J., Ames, Iowa.
Fisher, C. K., Alhambra, Calif.
Flanders, Stanley E., Saticoy, Calif.
Flebut, A. J., Berkeley, Calif.
Freeborn, Stanley B., Davis, Calif.
Gibson, Arthur, Ottawa, Canada.
Hagan, H. R., Salt Lake City, Utah.
Hamlin, J. C., Fresno, Calif.
Hassan, A. S., Berkeley, Calif.
Herbert, Frank B., Los Gatos, Calif.
Henderson, C. F., Oakland, Calif.
Herms, W. B., Berkeley, Calif.
Howard, L. O., Washington, D. C.
Hutton, C. W., Oakland, Calif.
Lamiman, J. F., Berkeley, Calif.
Larson, A. O., Alhambra, Calif.

Lewis, H. C., Sacramento, Calif.
List, Geo. M., Fort Collins, Colo.
Mackie, D. B., Sacramento, Calif.
Merino, Gonzalo, Manila, P. I.
Mote, Don C., Corvallis, Oregon.
Morrill, A. W., Los Angeles, Calif.
McGregor, E. A., Lindsay, Calif.
Packard, C. M., Sacramento, Calif.
Quayle, H. J., Riverside, Calif.
Reed, W. D., Fresno, Calif.
Schweis, Geo. C., Reno, Nevada.
Soliman, L. B., Cairo, Egypt.
Swezey, O. H., Honolulu, H. T.
Timberlake, P. H., Riverside, Calif.
Urbahns, T. D., Sacramento, Calif.
Vansell, Geo. H., Davis, Calif.
Weigel, Chas. A., Washington, D. C.
Wilson, C. C., Sacramento, Calif.
Woglum, R. S., Los Angeles, Calif.
Wymore, F. H., Davis, Calif.

REPORT OF THE TREASURER FOR 1926

Balance on hand, June 18, 1925		$12.82
Refund from main Association for 1925 expenses		14.65
Interest from bank		.62
Paid out—Postage and envelopes	$4.10	
Mimeographing notices	2.00	
Typing proceedings of Portland meeting	2.00	
Dues to Pacific Division A.A.A.S.	5.00	
Telegram	.30	
Total expended	$13.40	
Total received		$28.09
Balance on hand June 16, 1926	$14.69	

Organization of the main association.

Chairman Herms appointed the following committees:

Nominating: H. J. Quayle, C. M. Packard, T. D. Urbahns; Resolutions: O. H. Swezey, Don C. Mote; Membership: A. O. Larson; Affiliation: R. W. Doane, E. O. Essig; Auditing: S. B. Freeborn; Endowment: Don C. Mote, R. W. Doane, H. J. Quayle.

After some discussions by Freeborn, Mote, Woglum and Campbell, it was moved and carried to take up with the Pacific Division, American Association for the Advancement of Science, the matter of holding our meetings a little later in the summer, preferably in July or early August.

FINAL BUSINESS SESSION

CHAIRMAN HERMS: It is with the greatest of pleasure that I call on our President, Arthur Gibson, who has come all the way from Ottawa to attend these meetings.

PRESIDENT GIBSON: It gives me great pleasure to have the opportunity to attend these meetings. I have enjoyed them, and also meeting many persons whom I formerly knew only by name.

President Gibson then discussed several matters of importance, telling of the progress being made in the affairs of the Association. The matter of the endowment was referred to a committee, which was appointed to

assist the committee of the main association. Mr. Gibson closed his remarks with a cordial invitation to attend the Philadelphia meeting.

Chairman Herms of the arsenical residue committee reported that as the result of a meeting in Berkeley at which representatives of the State, University, and Federal Bureau of Entomology were present, a uniform set of recommendations were drawn up to distribute among interested parties, in regard to the control of the codling moth.

MR. T. D. URBAHNS: The State Department of Agriculture sent out several thousand of these recommendations, and also mailed them to the newspapers. New information is being sought for next year, with a view of revising and improving the recommendations.

MR. DON C. MOTE: We are interested in codling moth control in Oregon, and it seems to us that the present standard of 1/100 grain of arsenic per pound of apples is too small and we should make some effort to have this revised.

MR. T. D. URBAHNS: The California State Board of Health and the U. S. Bureau of Chemistry have decided to stand by the British standard of 1/100 grain per pound and apparently all we can do is to get the growers to produce apples according to this standard.

The auditing committee reported that they had examined the accounts of the treasurer, and had found them correct.

The resolutions committee reported as follows:

REPORT OF THE COMMITTEE ON RESOLUTIONS

Resolved: That a hearty vote of thanks be extended to the University of California and Mills College for their hospitality in providing us with a meeting place and accommodations to the members in attendance, and that the secretary forward a copy of this resolution to the Presidents of the respective institutions.

Resolved: That a vote of thanks be extended to our chairman and our secretary for the efficient performance of their duties in arranging of the program and conduction of the meetings.

Resolved: That we express our appreciation to Dr. L. O. Howard and President Arthur Gibson for their attendance, interest and participation in our meetings.

The membership committee presented the names of Kenneth E. Gibson and Marshall W. Stone for associate membership.

The nominating committee presented the following report:

For Chairman—R. W. Doane.

For Vice-Chairman—R. S. Woglum.

For Sec'y-Treas.—Roy E. Campbell.

The reports of the various committees were accepted. Mr. Geo. M. List called attention to the Rocky Mountain Conference of Entomologists, and extended an invitation to attend.

On motion the meeting adjourned, to meet next year with the Pacific Division, American Association for the Advancement of Science.

PART II. PAPERS AND DISCUSSIONS

Morning session, Thursday, June 17, 1926

Chairman Herms called on Mr. Don C. Mote to take the chair.

MR. DON C. MOTE: We will now proceed with the regular program, and listen to a paper by our chairman, W. B. Herms.

HIPPELATES FLIES AND CERTAIN OTHER PESTS OF THE COACHELLA VALLEY, CALIFORNIA

By W. B. HERMS, *Professor of Parasitology, University of California*

ABSTRACT

The Coachella Valley (California) borders upon Salton Sea, it lies on an average of about 125 feet below sea level and has a population of about seven thousand inhabitants among whom are many Mexicans and many transient negroes during the cotton picking season. During the past ten or more years Hippelates flies (*Hippelates flavipes*) have become increasingly numerous, until now they are a veritable pest and together with numerous cases of so-called "pink eye" affecting the people of the valley and the known relation of this fly to the disease, there exists a really serious situation. The breeding habits of the fly remain unknown as yet.

The black widow spider, *Latrodectes mactans*, occurs in the Valley in considerable numbers and several serious cases of spider bite have been reported with one fatality. The German cockroach (*Blatella germanica*) is increasing enormously in this region and is rapidly becoming a real pest.

Immediately bordering upon the northwestern edge of Salton Sea there lies one of California's most unique valleys, the Coachella. It averages about 125 feet below sea level, with very high summer temperatures and meagre rainfall, but blest with a good supply of excellent artesian well water. The inhabitants of the valley, many of whom are from the south, number about seven thousand and live largely in and about the communities of Indio, Coachella, Thermal and Mecca. There is also a large Mexican population and many negroes are transiently in the valley during the cotton picking season. The valley is particularly famous for its dates, there being about one thousand acres of this crop. Many other crops, also all under irrigation, such as cantaloupes, tomatoes, and so forth, thrive in this valley.

The writer's first visit to this valley was in 1909 (Mar. 17–20) when the first dates were being tested out, and the present state of development both agriculturally and socially was but a fanciful dream. At that time the few natives in this valley seemed to be greatly terrorized by the presence of solpugids (sun spiders) or "vinegaroons" as they were locally called. It was generally believed that the presence of one of these creatures in a watering trough would be sufficient to kill a horse. Many

other terrible stories about these "vinegaroons" were in vogue,—all without foundation.

The terror of the valley on this my most recent visit was not the solpugid, but the minute Hippelates fly which exists in countless numbers throughout the valley, and with it literally hundreds of cases of so-called "pink-eye" or catarrhal conjunctivitis, apparently the follicular form. According to a physician who has been a long resident in the Coachella Valley, the disease has existed there as early as 1912, reaching epidemic form in 1920 and 1921. According to the several druggists interviewed there was a big daily sale of argyrol and similar remedies, few cases came through the hands of physicians. Among the considerable number of families visited not one was without argyrol. Both the cases seen by the writer and those reported by druggists were practically all children, though adults are frequently affected.

All persons interviewed, Health Officer, physicians, druggists, and growers were agreed that the little "buzz gnat" had a more or less important part in the transmission of the disease. This is quite in accord with experience with this genus of flies and other flies as well in Florida, Egypt, India, Fiji and elsewhere, as reported by Howard,[1] Nuttall and Jepson,[2] and others. The infection is also carried by the hands, towels, handkerchiefs and other mechanical agencies through contact from sick to well.

The fly has been identified as *Hippelates flavipes* Loew, belonging to the family Chloropidae (Oscinidae). It measures about two millimeters in length, is active from daylight to dark from nine to ten months of the year, growing in abundance from April to September. It is a most persistent little creature buzzing around the head, settling momentarily on one's clothing, darting frequently at the eyes and into the ears. Drops of blood on the skin, open wounds, sores, mucous membranes, and so forth are particularly attractive to the flies.

Unfortunately the breeding habits of the flies are unknown. Persons living for many years in the Coachella Valley differ considerably in their opinions as to their appearance, some state that the formation of the Salton Sea was responsible for their appearance, others attribute it to the introduction of cotton, others to the Athol or Tamarix tree, still others

---

[1]Howard, L. O., 1911. The House Fly-Disease Carrier, Frederick A. Stokes Co., New York. XIX + 312 pp. (see pp. 167–170).

[2]Nuttall, G. H. F., and Jepson, F. P., 1909. The part played by *Musca domestica* and allied (non-biting) flies in the spread of infective diseases. Reports to the Local Gov't Board on Public Health and Medical subjects. London, N. S. No. 16, 13–41.

assert that the fly was imported with date shoots from northern Africa. Most everybody says if you really want to see "buzz gnats" go into the Bermuda grass. This grass grows profusely along the banks of irrigation ditches and is certainly largely inhabited by these flies which if the wind is not blowing swarm out in literal clouds and drive one back. No place, however, seems to be free from them,—screens on houses are, of course, ineffective. The flies appear to prefer brighter situations such as broad sunlight in the cotton fields and among the date palms. This situation presents an economic problem of considerable importance. In a petition to the University of California and the State Board of Health signed by many citizens of the Coachella Valley, these statements are made, "It is an actual fact that the value of residential and farm properties has been noticeably depressed by this situation.... Workmen, both in the field and shop, are very seriously hampered in their duties and animals suffer greatly." Fruit pickers are much hampered, pollinating dates is made difficult, school teachers are hard to keep, workmen in general will not stay on the job, absences among school children due to pink eye mount up.

In certain respects another arthropod is even more terrorizing than the Hippelates fly, namely, the "black widow" spider, *Latrodectes mactans* Fabr. One of the local physicians stated that he would rather be bitten by a rattlesnake (and these are present, too) than by a "black widow" spider. This physician stated that there had been one fatal case of spider bite and several others had been bitten with very grave results. The bites are usually inflicted on the scrotum while the person has been sitting in a field privy, commonly used in this valley.

A favorite nesting place for these spiders appears to be in the deep crevices at the bases of date palms. In these crevices the spiders spin a deep tubular web in which they hide during the day, evidently only one spider for each palm. The egg sac is usually to be found near the outer opening of this tube. Early in the evening the spiders come out and spin a large irregular web in front of the tube. During the evening that we made our examination of this situation (June 6, 1926) we found that many of the spiders had captured cicada pupae (cicadas were emerging in great numbers at the time), each spider having a pupa firmly tied to the middle of the web, and a feast was in progress. By the light of a flashlight the black glistening bodies of the spiders could be easily seen and many were captured. A small pump house in this same grove harbored a half dozen of these spiders, each in its own corner. Sociability is not an attribute of the "black widow."

The German cockroach (*Blatella germanica* Linn.) is increasing enor-

mously in this locality, being present in abundance both indoors and out-of-doors. Lifting up a door mat, for example, exposed a dozen or more of these roaches in various stages of development. They are to be found under rubbish and on the date palms much in the same manner as roaches inhabit coconut palms in the South Sea Islands. These roaches are becoming the despair of the housewives in this locality.

CHAIRMAN HERMS: The next paper is by H. J. Quayle.

CYANIDE DUST FUMIGATION FOR CITRUS TREES

By H. J. QUAYLE, *Citrus Experiment Station, Riverside, California*

(Withdrawn for publication elsewhere)

CHAIRMAN HERMS: We will postpone discussion of this paper until later, and view the film on The Mexican Bean Beetle, brought here by Dr. L. O. Howard.

CHAIRMAN HERMS: We also have a film on Malaria and the Mosquito, which we will show while the motion picture operator is here.

Adjournment at 12.15.

Afternoon Session, Thursday June 17

The meeting was called to order by Chairman Herms at 2. P. M. who announced the first paper by A. W. Morrill.

AIRPLANE DUSTING FOR THE CONTROL OF VEGETABLE PESTS ON THE MEXICAN WEST COAST[1]

By A. W. MORRILL, *Consulting Entomologist, Los Angeles, California*

ABSTRACT

During the first four months of the calendar year 1926 airplanes were used by vegetable growers on the West Coast of Mexico for the control of certain pests affecting their crops. The work was principally in the Fuerte Valley under the immediate direction of Mr. A. H. Amis and Mr. G. E. Paxton of the Estacion Experimental de los Cosecheros de Legumbres del Rio Fuerte (Fuerte Valley Vegetable Growers Experiment Station), of which the speaker is Director. Applications of insecticides and fungicides were made to approximately 7500 acres of tomatoes and 500 acres of peas. Tomatoes were treated with calcium arsenate for the

[1]Presented as an informal address illustrated with photographs and specimens.

control of tomato fruit worms,[2] with monohydrated copper sulfate and lime for the control of tomato nail-head disease,[3] with calcium cyanides for the control of the garden flea hopper[4], and with sulphur for the control of mildew of peas.[5] This was probably the first attempt to make applications of insecticides and fungicides to these crops with airplanes.

The principal factor which decided the question of the selection of airplanes for the protection of the tomato crop was the labor question. With more than 20,000 acres of tomatoes in one district, an increase of 100 per cent over the previous year, and with the prospect of a labor shortage during the height of the season it was evident that if any adequate protection were to be given it must be by means of airplane service. A single unit of this service with two pilots and a mechanic provided by the contracting company (Huff Daland Dusters, Inc.) with occasional assistance of a laborer or two in handling insecticides and fungicides, and under expert field supervision as already stated, was capable of doing field work which it would require a force of 1500 to 2000 men to handle with ground machinery.

In previous years we have used standard arsenate of lead powder for the control of the tomato fruit infesting worms, but in the winter and spring of 1926 following field tests of calcium arsenate this latter insecticide was adopted for the season's work. Heavy dews occur almost every night in the Fuerte Valley. Winds interfere with the applications of dust during the greater part of the daylight hours but not usually before 10 A. M. or after 5 P. M. In only one instance was calcium arsenate suspected of causing damage to plants. This was in a small area of about one-quarter of an acre where a very heavy dose of the insecticide accidentally reached the plants where the pilot zoomed up at the edge of the field. No injury to the fruit was noted, the suspected damage being confined to the leaves and tender shoots. In many other cases what appeared to be an equal amount of calcium arsenate apparently gave no bad effects.

Tomato plants are rather dense when of large size, and interfere more with the spread of the dust than do cotton plants. It was found that calcium arsenate could be effectively distributed in a swath of about 140 feet in width, or 70 feet on each side of the plane. From 4 to 12 pounds of calcium arsenate were used per acre, the amount depending upon the

---

[2]The bollworm, *Heliothis obsoleta* Fab. and the tomato leaf folder, *Phthorimaea glochinella* Zeller.

[3]*Alternaria solani* (E. & M.) J. & G.

[4]*Halticus citri* Ashm.

[5]*Erysiphe polygoni* DC.

size of the plants. When the purpose was to attempt to control the nailhead disease as well as the worms, the calcium arsenate was mixed with monohydrated copper sulfate and hydrated lime in the proportion of 25–12½–62½. Fully one-half of the acreage, however, was dusted with undiluted calcium arsenate. Chemical tests showed a gradual reduction in the amount of arsenate deposited on the leaves between 30 and 90 feet from the line over which the airplane passed. Designating 100 as the dosage in the central 60 foot swath where the distribution was apparently quite uniform, the dosage at 90 feet amounted to 60. The overlapping of the dust clouds tended to correct this unevenness of distribution as shown by the examinations of a single swath. Everything considered it was believed by Messrs. Amis, Paxton and the writer that the evenness of the distribution and the penetration of the vines was such that there was a decided advantage in the distribution of the dust by airplane as compared with ground machines.

While it was impossible to follow up the results in a statistical way as closely as would have been done if the work had been purely an experiment, it is interesting to note that during the period when there was a normal increase in the numbers of the fruit infesting worms, numerous field counts showed very striking results. The results during the latter part of the season when the worms were more abundant were much more positive than earlier in the season when the percentage of infestation was normally less than 15 per cent. There were no exceptions discovered where the results were negative. In one instance the dusted field showed only 4 per cent damage while an adjoining undusted field of approximately the same age and condition showed 40 per cent damage. In another instance a count showed 14 per cent damage in the dusted field as compared with 48 per cent damage in the check undusted field. In a third instance the dusted field showed 24 per cent damage, whereas an undusted portion of the same field showed 76 per cent damage. In this last instance it was noted when the counts were made that a conspicuous portion of the 26 per cent counted as infested in the dusted field consisted of tomatoes having worms which had hatched within a week, in some cases not having penetrated the fruit at the time of examination. The percentage of these young stages in the undusted portion of the field showing 76 per cent infestation was much less. This observation indicated that while the results of a single application of the dust were very satisfactory a second application made ten days previous to the count would undoubtedly have held the infestation of the dusted down to close to ten per cent. The tomato leaf folder greatly predominated in numbers over the bollworm.

The most important experimental work consisted in the use of calcium cyanide compounds in an effort to find a satisfactory control for the garden flea hoppers in tomato fields. Among the materials tested were Calcyanide No. 3 (Dust), Cyanogas Calcium Cyanide "A" Dust, Cyanogas Cinch Bug Flakes and Cyanogas Calcium Cyanide Granules.

It was found that the finer calcium cyanide dusts and dust mixtures which evolve the cyanogen gas in a comparatively brief period were ineffective for dusting in open fields. The insects were readily stupefied in areas where the dusts were applied, provided the air was reasonably quiet, and they frequently remained in this condition for three or four hours following the application of dust. A large number of these stupified flea hoppers after several hours without noticeable movements quickly revived and became apparently normal. Comparatively few of the insects were killed, and the nymphs were no more susceptible to the gas than were the adults.

The granular and flake forms of calcium cyanide were then tested and the preliminary experiments showed that these materials affording a slow generation of the gas gave entirely different results. Using from 40 to 60 pounds of calcium cyanide flakes per acre applied by airplane late in the afternoon when the air was comparatively quiet frequently gave kills of practically 100 per cent. On the other hand for some unexplained reason unsatisfactory results were secured in certain experimental applications. In some cases no injury to the tomato plants resulted while in other instances the plants were almost completely killed with approximately the same dosage. The principal problem with which we were confronted was in discovering a method of cleaning up the field regardless of the effects upon the plants. Tomato fields in a limited area of about a square mile were so heavily infested with the garden flea hoppers that the late setting of fruit was ruined, and it became essential to destroy the insects almost regardless of expense in order to prevent the spread of the adults to adjoining lightly infested fields.

Airplane applications of granular and flake cyanides were made from a height of 25 feet, or two or three times as high as in the case of calcium arsenate. The spread of the flakes was found to be over an area of only 15 to 20 feet on each side of the plane. The cost of the airplane service for this work therefore was proportionally much higher than where a powder was used. After calcium cyanide flakes were selected for the principal work with the flea hopper later experiments indicated that the granular form may after all be preferable. The work is far from conclusive and we do not feel justified in doing more than offer a brief

statement of our experience without conclusions or recommendations.

While sulphur was applied by airplanes for the purpose of controlling a plant disease, since this material has occasional uses as an insecticide it is worthy of note here that 15 pounds of sulphur dust per acre distributed by airplane gave as effective control of pea mildew as was obtained at the same time in other fields in the same district with applications by ground machines and by shaking from sacks of amounts ranging from 30 to 40 pounds per acre. Probably the amount used with the ground machines and hand applications might have been reduced without loss in effectiveness but this point was not investigated. It may at least be said that as with arsenicals for the tomato worms the airplane permits of minimum dosages.

The use of aeroplanes in dusting to control various insects was discussed by Dr. L. O. Howard, Don. C. Mote and A. W. Morrill.

CHAIRMAN HERMS: The next paper will be presented by A. O. Larson.

OBSERVATIONS ON THE CHARACTERISTIC INJURY CAUSED BY THE LIMA BEAN POD BORER, *ETIELLA ZINCKENELLA* TREIT., AND OTHER INSECTS WITH WHICH ITS INJURY IS CONFUSED IN CALIFORNIA

By A. O. LARSON, *U. S. Bureau of Entomology*

ABSTRACT

After beans are threshed in California the injury to insect damaged beans is often charged to the wrong insect. This paper gives the characteristic appearance before and after harvest, of beans cut by the lima pod borer as well as that of beans injured by other caterpillars and bean weevils.

My work with bean weevils in California continually brings me in contact with the injury caused by the lima bean pod borer. In some instances infestations reported to have been caused by the bean weevil have proved to be the work of the pod borer, and in other instances the bean weevil has been reported as the culprit when the pod borer has actually been the guilty party. Yet there seems to be no good reason for mistaking the injury caused by the one for that of the other, since the method of attack in each case is so different. Moreover, varieties of beans attacked are usually different also. The pod borer practically confines its work to the limas, attacking all varieties grown in the state, including the large varieties, *Phaseolus lunatus macrocarpus*, the bush or baby varieties and the Moki or Hopi, *P. lunatus*. It may occasionally attack the black-eyed cowpea, *Vigna sinensis*, as well as the common

bush and pole beans, *Phaseolus vulgaris*, but from my own observations I should say practically all of the injury to these varieties which is usually attributed to the pod borer is actually caused by several other caterpillars.

Before harvest most of the damage to the black-eyed cowpea and to common beans caused by other caterpillars can readily be distinguished from that of the pod borer by the feeding scars in the pods. Half-grown caterpillars eat a large hole in the pod and consume part or all of a bean only a short distance from the point at which they entered, or they eat away a good deal of the pod and a part of the bean without entering the pod. In the one case the caterpillar is partially visible while it is feeding, and in the other it remains entirely outside of the pod. The pod may be attacked in more than one place. In the case of the black-eyed cowpea one caterpillar will frequently attack every pod on a scape or several pods on the same bush. With the common beans the attack is quite often confined to pods which touch the ground.

Sometimes the pod borer is charged with damage caused by the western spotted cucumber beetle, *Diabrotica soror* Lec., which devours part of the pod of the common bean and some of the bean beneath it. Its attack on the pods is confined to those in which the beans are quite watery. The scar is not very large, but it usually turns brown and arrests the development of the bean attacked.

In California the Southern cowpea weevil, *Bruchus quadrimaculatus* Fab., confines its attack almost entirely to the black-eyed cowpea. It will oviposit freely upon the limas and several varieties of common beans in storage as well as upon a great variety of other seeds in which it is unable to develop.[1]

The common bean weevil, *Bruchus obtectus* Say, works freely in the common beans and black-eyed cowpeas and to a limited extent in the limas, but its attack is very different from that of the pod borer. The adult beetle makes a tiny hole in the suture of the well-matured or ripe pod and inserts its numerous eggs inside of the pod. After hatching, the larvae bore almost microscopic entrance holes into the beans. Several larvae may attack one bean, but one larva does not attack more than one bean. A careful inspection is necessary in order to see either the oviposition scar in the pod or the entrance hole in the bean. To the casual observer the first evidence of weevil injury is the emergence holes in the beans after they are threshed, but to the experienced eye holes in the pods are visible before they are threshed, and darkened

[1]A. O. Larson. The Host Selection Principle as Applied to *Bruchus quadrimaculatus* Fab. Unpublished manuscript.

spots or windows are seen in the threshed beans before the weevils emerge. The weevils continue to breed, generation after generation, in stored beans until all available food has been consumed. They depend upon the shipment of infested beans for their wide distribution, and upon their power of flight for their more important local dissemination. They never injure the first crop of beans grown in a new locality unless introduced by man and furnished a breeding place for one or more generations while the crop is maturing.[2]

The pod borer is the larva of a moth which lays its eggs on the outside of the growing pod or other part of the plant. After the egg hatches the larva bores into the green pod, where it feeds upon the growing beans. As the pod develops, the larval entrance hole heals over, leaving only a small black or dark spot. This spot often remains visible even after the pod has ripened. The larva, while remaining concealed within the pod, proceeds to devour all or part of a seed and then moves to the next, but it does not enter the bean as the bean weevil does. Its incisions are rough and irregular, remaining thus after the bean is dry. Even where only a tiny hole has been made in the bean, the rough irregular incisions clearly separate its injury from the emergence hole of the weevil with its smooth, regular, circular edges.

The larva of the pod borer will sometimes devour only one large seed before it bores out of the pod to pupate. Usually it eats only one-fourth to one-half of the seed before going to the next. Frequently every seed in the pod is ruined. The presence of the borer can often be detected by the darkened color of the pod directly beneath the partially devoured bean. Some of the larvae, after boring out of the pods, return and pupate within, whereas others, apparently the great majority, pupate in the ground or under dried leaves at the base of the plant.

This insect does not work in dried beans in storage. Although it is shipped to local markets inside of green lima bean pods, it is not dependent upon commerce for its distribution. Unlike the bean weevil, it frequently destroys almost every bean in a crop of bush limas in a section where they are grown for the first time.

In 1921 about one-half acre of Henderson bush limas was grown in Puente as a variety test. They throve so well that the owner expected to grow them to the exclusion of other varieties, but when they were threshed he found ninety per cent or more of them damaged by worms. The next year another grower planted a field to Henderson bush limas about five miles away from the field mentioned above, and obtained

[2]A. O. Larson and C. K. Fisher. The Role of the Bean Straw Stack in the Spread of Bean Weevils. Journal of Econ. Ent., Vol. 18, October, 1925.

similar results. In San Bernardino County as well as in the Antelope Valley wherever these beans were grown for the first time they were eaten up by the pod borer. In 1924 in Chino two rows of limas were planted between rows of red kidney beans and rows of black-eyed cowpeas. Until they were threshed they looked as if they might become the major bean crop of that section, just as they are in the San Fernando Valley, but before they were cut it became evident that the borer was at work in the pods, and when they were threshed it was found that almost all of the beans had been damaged. Similar instances have come to my attention in Stanislaus County where this crop had not been grown previously.

In addition to the places named above, I have noted the pod borer in lima beans at San Diego, Irvine, Owensmouth, and Ventura. At Ownesmouth, I found eggs, larvae in different stages of development, pupae, and adults in the same field at the same time. I have also bred this borer from three varieties of lupines, Lupinus sp. collected near Hickman and Hilmar.

The lima bean pod borer is so well distributed over California even where lima beans have never been grown that it seems to be indigenous, breeding in the native lupines, which are so very abundant over much of the state.

Some growers maintain that late limas are injured more than the early ones. My observations confirm this belief and indicate that a greater percentage of the crop is damaged in small isolated fields than in large acreages, and also that there are two or more generations of the pod borers.

The heavy infestation of the late limas appears to be caused not only by the moths which move in from native lupines or other native food plants but by a generation which has developed in earlier limas in the vicinity. It appears that the infestations are somewhat dependent upon the time at which the lupines dry up. If there is insufficient moisture only a few pods form. These ripen early and the plant dries up. The emerging moths are forced to seek other food thereby causing a heavy infestation in the early limas. When there is sufficient moisture there is an almost continuous crop of lupine pods and relatively few moths attack the early limas. The larvae appear to have little difficulty in adapting themselves either to the lupines or the lima beans.

CHAIRMAN HERMS: We will now take up the Symposium, held jointly with the Pacific Coast Entomological Society, on the subject: The

Fundamental Value of Life History Data. The first paper is by Dr E. C. Van Dyke and will present the subject from the viewpoint of the Systematist.

THE VALUE OF LIFE HISTORY STUDIES FROM THE VIEWPOINT OF SYSTEMATIC ENTOMOLOGY

By EDWIN C. VAN DYKE, *University of California, Berkeley, Calif.*

ABSTRACT

To properly know and place each insect, one must have an exact knowledge of its structure,—insect morphology; an understanding of the uses of these structures and the causes of their appearance,—insect physiology; an idea of the ways in which these have been modified through time,—insect phylogeny; how they are developed,—insect embryology and metamorphosis. Insect biology and insect morphology are of equal importance to the student of systematic entomology and this is illustrated in the growth, transformation, adaptation and sexual needs of certain species such as *Papilio marcellus* Cram., *Cyllene robiniae* (Forst.), *Cyllene caryae* Gahan, and in such genera as *Malacosoma*, *Euphydras* (Lepidoptera), and *Colpodes* (Coleoptera).

To properly estimate the value of life history studies of insects to systematic entomology, one has first to define what is systematic entomology and what are its needs, and second, what does the study of the life history of insects teach us. Only by answering these questions can we arrive at a proper understanding of the subject.

What is systematic entomology?

To many people it is nothing more than the mere labeling of insects but that is the opinion of the ignorant. It is a much bigger subject and it requires as profound a knowledge of biology as any department of the same. Systematic entomology is the study of the relations which insects bear to each other and to other organic beings, those of the past as well as of the present. For purposes of convenience they are given a designation and in our literature are generally listed in an orderly manner, the arrangement showing as far as we can their supposed relationships. To properly know and place each insect, we must have an exact knowledge of its structure, insect morphology; an understanding of the uses of these structures and the causes of their appearance, insect physiology; an idea of the ways in which these have been modified through time, insect phylogeny; how they are developed, insect embryology and transformation; and the causes which have brought about the various modifications of structure and function, which are to a great extent inherent within the insects themselves and to an equal degree produced from without by those intangible influences which we are pleased to speak of as environment. The life history of an insect is the history of the insect

from its earliest conception within the body of its parents, through the egg stage and succeeding period of transformation until it becomes a sexually mature organism. A study of life histories, therefore, gives us a knowledge of how the various organs and structures are formed and modified, an idea of the uses to which these are put, as well as an understanding of the various ways in which the insect is adapted to its environment throughout its existence. Insect biology and insect morphology are thus interdependent and as a result, of equal importance to the student of systematic entomology. To bring out this fact, I shall now discuss the subject more in detail and from such aspects as that of growth, transformation, adaptation, and sexual needs.

A study of growth tells us what the various factors are which have to do with the development of body structures. It shows us how easily these may become modified, how definitely these modifications are synchronized with the modifications of other structures, and thus enables us to evaluate the importance of the various structures themselves. In explanation of this point, I shall cite two cases, that of the male Lucanidae or stag beetles and that of one of our most interesting eastern swallowtailed butterflies. The stag beetles are specially characterized by having the mandibles of the males greatly developed and accompanied with a compensatory enlargement of both head and prothorax. In addition the legs of the males are generally proportionally longer than are those of the females. These insects live in old decaying wood during their larval period and in general take several years to complete their development. When conditions are of the best, that is, of the optimum type with the woody food sufficiently moist, abundant and nutritious, and the temperature proper, the males will emerge at the end of their life cycle, fully formed and of characteristic type. If, however, conditions are not of the best, the wood too dry, lacking in amount or in nourishment, or the temperature too low, the male beetles will reach maturity in due course of time but they will lack the size, the excessive development of head and prothorax, and the large and complex mandibles. They will, in fact, quite closely simulate the females in structure. To the systematist who did not know the biology of these insects and the fact that the adult structures were modified by the nature of the larval food and environment, these two types of beetles would be listed as distinct species, as similar cases have been time and time again. The butterfly is *Papilio marcellus* Cram. (the *ajax* of most authors) which feeds on the papaw, *Asamina triloba*, and is three-brooded. The members of the early spring brood are of moderate size and with tails to hind wings straight and not very long. Those of the second brood are

somewhat larger, with longer and more curved tails while the adults of the third brood are characterized by having very long and curved tails. The members of each brood were at one time thought to be distinct species and were described as such, the first as *walshi* Edw., the second *telamonides* Feld., and the third *marcellus* Cram., and it was not until the species had been consecutively reared through all broods by W. H. Edwards that they were found to be but seasonal modifications of one species. The degree of development and modification produced were such as had been caused by the nature of the food at the time of larval development acting in conjunction with climatic influences, for later experiments showed that the various modifications could be hastened or retarded by changing these. The case of the stag beetle and that of the butterfly are but two of the many which might be mentioned. In fact, every insect shows that it has been modified to a greater or less degree during its period of development by the varying conditions which have been present during that period. A knowledge of the complete biology of an insect is therefore essential in many if not most cases if we are to properly interpret the various structural modifications that are to be found in insects.

The life histories of insects teach us far more than the mere appearance of the insect during the various stages of its existence. The sequence of changes that an insect undergoes as it develops is in a way but a recapitulation of the modifications which have occurred to the insect during the process of its evolution from its ancestral type. As a result a complete study of the earlier stages of insects throws much light upon their phylogeny and so enables us to more readily realize the value of certain structures as well as to more definitely map out their broader taxonomic relations. Thus we can feel justified in assuming that all winged insects came from wingless ancestors because of the fact that the larval stages of all insects are wingless and confidently state that the Thysanura and their close relatives are primitive types of insects because they are not only without wings as well as show no evidence of having been derived from winged ancestors, but closely resemble in many ways the earlier stages of those insects which acquire wings in the mature state. Embryology still further extends our vista: it gives us a cue as to what the ancestors and affinities of insects were as well as answers many questions concerning the primitive nature of certain of their structures.

Insects in all periods and all stages of their development have adapted themselves to various environments. With this has come modification, sometimes merely physiological but in most cases structural as well. Many of these show only during the earlier stages like the various hairs,

spines and color patterns of larvae, which are of course of value to the insects only during this stage and are thus of a transitory nature. Other modifications acquired in the earlier stages are carried through to the adult period as is the case with the scale-like covering of most Coccidae or scale insects. To the taxonomist, a knowledge of these early appearing modifications is often of great value, for it enables him to readily separate many species which otherwise might be hard to differentiate because of the very similar appearance of the adults. Cases in point are the various species of the tent caterpillar moths of the genus *Malacosoma* and many butterflies of the genus *Euphydryas* (*Melitaea*). The larvae of these are often very different in appearance while the adults are surprisingly uniform. It is, however, the adaptive modifications that are restricted to the adult stage which are most useful to the systematist and his attention is most readily drawn to these through a study of the habits of the insect. A specialized type of life begets a specialized type of being. A knowledge of this enables the student to seek out and find characters which are fundamental yet because of their inconspicuousness might readily be overlooked. The Coleopterous genus *Colpodes* is definitely separated from the genus *Platynus* only by the fact that the fourth tarsal segment is lobed in the former and not in the latter. The species of *Colpodes* are dominantly holotropical and arboreal, the dilated and lobed tarsal segment being an adaptation to arboreal life, whereas the species of Platynus are in the main holoarctic and terrestrial. An examination of insects which are partially or wholly nocturnal often shows that there is a very great variation among closely related species as regards the size and shape of the eyes, also often associated with striking compensatory modifications of the antennae. These show the degree to which the insect is adapted to the nocturnal life. Other modifications of a like degree of variability are to be found among subterranean insects. These are all such as might be easily overlooked but armed with a knowledge of the habits of the insect, one seeks out for such things and is generally rewarded. Many species of beetles and bugs are definitely restricted to certain food plants and many bees, flies, and moths only frequent special types of flowers. Certain of these closely resemble each other and though specifically distinct would not be suspected as being so except for the differences in their life histories. A good illustration of this is shown in the case of *Cyllene robiniae* (Forst.), the locust borer, and *Cyllene caryae* Gahan, the hickory borer.

The sexual and reproductive needs of insects have a decidedly modifying influence upon their life histories and this in turn produces structural changes of equal moment. To understand one, you must know the

other, thus the taxonomist in order to evaluate the characters developed in response to these needs, must know something of the factors which have produced them. The length of the ovipositor of the Ichneumonidae and their relatives is generally determined by the distance to which they have to drill in order to place their eggs where the larvae will most readily find suitable food. The rostrum of the female weevil has, no doubt, had its length determined by similar needs. The female insect which has to provide against great losses during the larval period, does so by increasing the number of eggs which she lays. This necessitates a great increase in the size of her body and in general a disproportionate enlargement of her abdomen with the result that she often becomes too heavy to fly. The wings through disease soon atrophy and in time we have a wingless female. Instances of this sort are common: we find them among the Acrididae or grasshoppers; in the Scarabaeidae, Elateridae, Meloidae and Chrysomelidae of the Coloptera; and among many families of the Lepidoptera. Insects which have to scatter widely because of the nature of their food often have to develop their special senses and wings to an extreme degree in order to enable the sexes to find each other. These modifications are generally accentuated in the males and show in such ways as the enlargement of the eyes and increase in length and complexity of the antennae. Other modifications for the same purpose are the development of light organs, most evident in the females, and the development of scent glands. The number of secondary sexual characters developed in insects is in fact very great and they are of very diverse types. They are all of especial interest to the systematist inasmuch as they are more or less distinctive of each species, but to make use of them to the best advantage, he must know the reasons for their existence and these, of course, can only be learned by studying the living as well as dead insect.

The discussion of this subject might be easily lengthened but I think that I have given enough to show that the systematist cannot be a first-class one and merely know the characters of the adult insects alone. He must also know the significance of those characters and there is no better way of getting that information than by studying their life histories. Thus, I feel that I am justified when I state that a knowledge of the life histories of insects is of paramount importance to systematic entomology.

CHAIRMAN HERMS: The next paper on our general topic is by H. S. Smith and will be read by H. J. Quayle.

THE FUNDAMENTAL IMPORTANCE OF LIFE-HISTORY DATA IN BIOLOGICAL CONTROL WORK

HARRY S. SMITH, *University of California, Riverside*

ABSTRACT

The various ways in which a knowledge of the different phases of the life-history of entomophagous insects is essential in biological control work are discussed. The most important requirement is the determination of the exact host-relationship of the parasite. Then a knowledge of oviposition and mating habits is shown to be essential to the successful rearing and colonization of beneficial insects. The relation of parthenogenetic reproduction to the establishment of exotic insects is also considered and the question of antagonism between two species attacking the same stage of the host is discussed. It is pointed out that the more detailed the life-history knowledge, the greater are the chances of successful work with entomophagous species.

A knowledge of the biology of any insect is essential to the control of its activities by man. This is so obvious that its demonstration is unnecessary. It is just as true in the case of useful or beneficial insects as it is with insect pests. Since this general statement is surely acceptable to all entomologists, this paper will be devoted to a discussion of some of the ways in which life-history data are essential in biological control work.

It is inconceivable that any entomologist could conduct intelligent economic work with a parasitic insect the life history of which he did not know in considerable detail. Not only is the *successful* outcome of his efforts dependent upon such knowledge, but even more important, lack of such knowledge may even lead him into errors which are irreparable. It is not possible, though once thought to be, to determine the habits of a parasite by its systematic relationships. There are groups of parasitic Hymenoptera which are largely primary in habit, and other groups which are largely secondary, but the extension of knowledge of their life histories has shown that in the so-called primary groups, secondaries are to be found and in the secondary groups certain species are primary in habit. The supposed correlation between taxonomic position and habit has so often broken down as the various species have been studied, that it is now considered essential to look upon every species with suspicion, at least in the Hymenoptera, until its life-history is definitely known. The strongest argument therefore which may be brought to bear on the necessity for life-history data in connection with biological control work is the absolute need of a determination of the exact host-relationship of the parasite; that is, whether it is primary or secondary in habit.

In a recent article[1] Dr. L. O. Howard pointed out an example of the

[1]Jour. Econ. Ent. Vol. 19, p. 274.

introduction of a secondary parasite about twenty-five years ago which has resulted in nullifying the effectiveness of the recently introduced *Aphycus lounsburyi* in coastal areas of California, where for the first two years it gave an almost perfect control of the black scale. It is entirely possible that this single mistake may prevent for all time the control of this serious pest by the biological method since the secondary, *Quaylea whittieri*, seems to attack any primaries on any but the early stages of the scale, the stages in which the parasites would probably prove the most effective. This introduction was due entirely to a failure to obtain the necessary life-history data, even a slight knowledge of which would have prevented this unfortunate occurrence. Detailed records of this introduction are not available but so far as known those who received the material from Australia and who were responsible for the introduction, assumed that it was primary in habit because of the fact that it issued in large numbers from the scale and was perhaps the only parasite to issue. Our observations on the way this secondary works in California indicate that under favorable conditions it could destroy practically 100 per cent of its host, and if the shipment was despatched at the correct time from Australia nothing but *Quaylea* would issue from the scales on arrival in this country. Either a careful study of the host remains or an attempt to breed the parasite on parasite-free black scale would have yielded data which would have prevented the introduction.

Even in the colonization of entomophagous insects which are definitely known to be primary it is necessary to make certain that the individuals placed in the field are not parasitized by secondaries. The colonization of adult parasites may ordinarily be depended upon to be safe. The placing out, on the other hand, of any of the immature stages of the parasite is accompanied by considerable risk and the avoidance of this is possible only through a knowledge of the life histories and habits of the secondary parasites which attack them. The habits of these insects are sometimes quite complicated and of such a nature that even a cautious entomologist might be thrown off his guard, if he lacked a knowledge of their biology. A few years ago, for example, one might have assumed that if he imported young Gipsy moth caterpillars from Europe, reared them in the laboratory in insect-proof cages until the Tachinids emerged, he might safely colonize the puparia thus obtained in the open, since there had been no opportunity for parasites to attack them after issuance. At the Gipsy moth laboratory, however, puparia obtained under these conditions produced the secondary parasite *Perilampus* in considerable numbers. It happened that this particular Tachinid was one which hibernated in the puparium stage and they

were placed out-of-doors in the soil for overwintering. They were enclosed in tight screen cages, not for the purpose of keeping the secondaries in but to protect them from destruction by native enemies. The method by which these secondaries gained access to the Tachinid puparia was a mystery.

At about this time, however, a study of the natural control of the fall web-worm was undertaken, and among the parasites reared was a species of *Perilampus* parasitic on the Tachinid *Varichaeta*. Briefly, it was found that the first stage larvae of the secondary parasite bored their way into the caterpillar, exploring its interior until they located the larva of the primary parasite, into which they made their way. They then remained quiescent until the primary had left the host and pupated, when they began feeding and development. It was later found that *Perilampus* is a leaf-ovipositing genus and that the first-stage larvae probably attach themselves to the caterpillar in a way similar to that adopted by the Meloid beetles parasitic on bees.

It will be seen from this that a lack of knowledge regarding the life histories of the parasitic Hymenoptera in general might easily result in the unintentional introduction of a dangerous secondary parasite.

That life-history data is absolutely essential to the successful introduction and propagation of parasitic insects seems so obvious as hardly to be worthy of comment. A few illustrations may, however, be of interest. Most parasites which issue from the larvae or pupae of their host deposit their eggs in one or the other of these stages. Nevertheless, it is now known that several groups of such parasites do not do this, but instead deposit their eggs in the eggs of the host insect, there to remain quiescent until the host hatches and develops. The Serphoid parasites Polygnotus and Platygaster, the Chalcidoid Copidosoma and related genera, the Braconid Chelonus, all have this habit. Lacking a knowledge of this, one might easily be mislead into attempting to secure oviposition in the later stages of the host, which would of course result in failure. Such mistakes are serious when one is attempting to propagate imported species which, as a general rule, are received in limited quantities. It is therefore one of the first essentials of this type of work that the oviposition habits of the parasite be determined.

Somewhat related to this is the question of mating. Almost all parasitic Hymenoptera deposit eggs which will develop regardless of whether or not they have been fertilized. By far the majority of them, however, produce males only, from unfertilized eggs. In introducing most exotic species, therefore, or in attempting to propagate them in confinement, it is essential that mating take place in order to increase the

stock. This is not always easy since some species will mate only under special conditions.

An interesting illustration of the importance of this factor occurred in connection with the attempt to introduce the Braconid *Meteorus versicolor*, a parasite of the Gipsy and Brown-tail moths, into New England from Europe. This parasite generally occurred only in very small numbers in the shipments of French caterpillars received at the Gipsy moth laboratory. In order to give them a chance to become established in the open, it seemed necessary to increase their numbers by laboratory propagation. Small colonies, including both sexes, were placed in cages with a liberal supply of young caterpillars. Oviposition took place freely and in due time a nice supply of cocoons of the parasite appeared and the attempt to propagate them seemed successful. Much to our surprise and disappointment, when the adults emerged from the cocoons they were without exception all males. This indicated that fertilization had not taken place. Later attempts ended in a similar manner. It was finally decided that the only thing to be done was to place the adults reared from foreign caterpillars, even though few in number, directly into the field. In carrying such a colony to the woods one morning the glass container was struck by the direct rays of the sun and immediately mating took place among the *Meteorus*. The secret was out and after that no difficulty was experienced in propagating this parasite. It was necessary only to place the adults in the sun in order to get female progeny. Since that time we have observed this phenomenon to occur in other parasites, and undoubtedly other species require still a different stimulus before mating takes place. For example, Kamal has found that certain Ichneumonid parasites of Syrphidae will mate in confinement only when in the presence of their host.

Another important point along this line which must be determined is the time which must elapse between emergence and mating. It is almost useless to place colonies in the open before the females have been fertilized, since their first instinct is to disperse and the chances of the two sexes meeting afterward are slight. Most Hymenopterous parasites are ready to mate almost immediately upon emergence, but many of the Tachinidae, I believe, mate only after some time has elapsed. Some of the Coccinellidae will mate only after ten or twelve days. This necessitates holding them in confinement until they have reached the proper stage of maturity. The length of time necessary to hold them, therefore, is an important phase of their life history which must be determined before they can be intelligently handled.

The phenomenon of parthenogenesis is of more than academic interest

in connection with biological control work, since it may have an important bearing on the establishment of an exotic parasite in a new region. One of the principal difficulties to be met in this work, as mentioned in a previous paragraph, is the question of the production of female progeny, since obviously unless the introduced individuals produce at least a portion of females, the colony cannot persist long enough to become permanently established. This difficulty does not exist in the case of those parasites which produce females from unfertilized eggs, and thus their establishment is rendered much easier, since a single female is sufficient to start a colony if other conditions are satisfactory. In attempting the establishment of exotic species it is important therefore to determine whether the parasite is thelyotokous or arrhenotokous, and be governed accordingly. I believe it is the general opinion of parasitologists that large colonies of introduced species are desirable because of this question of mating. It does not apply, however, in the case of thelyotokous species, and single individuals or small colonies of species having this characteristic may properly be liberated.

Occasionally a knowledge of this phase of the life history of a parasite may be very useful. For example, in the work with Gipsy moth parasites in Massachusetts, the early shipments of the egg parasite *Schedius kuvanae* from Japan produced only a very small number of individuals and these were all females. It would have been useless to attempt to colonize these individuals, since they produce male progeny if unfertilized and the colony would have failed to survive. This dilemma was overcome in the following way: The female Schedius were permitted to deposit a part of their quota of eggs in the eggs of the Gipsy moth. These females were then fed with sweetened water and placed in a refrigerator under such conditions as would serve to prolong their life to the greatest possible extent. At the same time the Gipsy moth eggs containing the eggs of the parasite were placed in an incubator so that their development would advance as rapidly as possible. In due time these eggs produced an abundant supply of male progeny. These males were used to fertilize their mothers, whose lives had been prolonged by refrigeration. These then fertile females were used to parasitize additional Gipsy moth eggs and from these an abundant supply of female Schedius was obtained.

A knowledge of these phases of the life history of a parasite may thus often be of practical use in biological control work.

One of the fundamental requirements in work with beneficial insects is the synchronization of the life histories of parasite and host insect. Unless the two are properly synchronized there is little possibility of

effective work. The parasite may become permanently established, but unless its efficiency can increase concurrently with the increase in abundance of the host it is not likely to prove of much practical value. This can happen only when the life history of the parasite is closely adapted to that of its host. Otherwise there will be a period during which the parasite's increase will be checked while that of the host will not be, with obvious results. With a definite knowledge of the life histories of both, it is possible to foresee, in some degree at least, whether or not the two will synchronize.

During recent years there has been considerable interest shown by parasitologists in the question of antagonism between primary parasites of two or more species attacking the same stage of the host insect, sometimes known as multiple parasitism. This interest has arisen from a situation in the Hawaiian Islands in connection with the introduction of parasites of the Mediterranean Fruit Fly. Two species of primary parasites, *Opius humilis* and *Diachasma tryoni*, both attacking the same larval stages of the host, were successfully established in the Islands. Most of these parasites do not distinguish between parasitized and unparasitized hosts, and there often arose a condition where both species attacked the same individual. Since both parasites cannot mature in the same host, the one best fitted to survive destroys the other. It happens, however, that *Diachasma tryoni*, which is the one which survives this competition, is much less effective as a fruit-fly parasite, by itself, than is its rival. Therefore, it is reasoned, the introduction of *D. tryoni* was a mistake, since *Opius humilis* alone would have proven more effective than the two together. While not wishing to question this conclusion, it does not seem entirely clear to the writer that the combined efforts of the two species result in a lesser destruction of fruit-flies than would have been the case if Opius alone had been introduced. Since Opius is the more rapid breeder, it seems possible that the destructive effects of *superparasitism* might have been greater, if it alone had been introduced, than the adverse effect of *multiple parasitism* due to the presence of *Diachasma*. It is a rather difficult matter to determine. Assuming, however, that such injurious effects do occur, they could be avoided only by a detailed knowledge of the life histories of the parasites, not only by themselves, but in combination, and under exactly the same environmental conditions as they will encounter in their new habitat. In actual practice it would be extremely difficult, if not impossible, to reproduce the exact habitat or environment under controlled conditions. Furthermore it would take years of study and would greatly delay the introduction of beneficial insects. Carried to its

logical conclusion it would mean that no entomophagous insects would be introduced until complete knowledge was available with reference to all the parasites and predators of a particular pest throughout the world.

Undoubtedly, in certain cases, one could determine before introduction, which of two primaries was the more effective, and he might be justified in assuming that both of them would actually accomplish less toward the control of their host than one of them would alone. The question goes much farther, however, than the matter of two primaries attacking a single stage of the host in competition. The relation between the predators and parasites attacking the same host is of the same type. For example, ladybird enemies of scales destroy unparasitized scales and parasitized scales alike. Some have argued that for this reason we should not introduce ladybirds. Every parasitologist knows that there is this overlapping, and that the total efficiency of two competing species is considerably less than the sum of that of the two working independently. So long, however, as the dominant species does not actually *show a preference for* host individuals attacked by the other species, the total efficiency should be at least somewhat greater than that of either working alone.

Our very limited knowledge of the factors which determine the abundance of both host and enemy makes it difficult to predict the outcome of introductions of exotic species, but experience has taught us that certain life history data are indispensible to the intelligent and safe prosecution of biological control work. All such data would be desirable, but as in most work in applied biology, we can only approach the ideal; we cannot attain it.

CHAIRMAN HERMS: The next paper is by O. H. Swezey.

RECENT INTRODUCTIONS OF BENEFICIAL INSECTS IN HAWAII

By O. H. SWEZEY, *Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii*

ABSTRACT

In Hawaii, the introduction of natural enemies for the biological control of insect pests continues to be the method chiefly employed. During the period 1920–1925 inclusive, the important successful introductions were as follows:

1920—*Cyrtorhinus mundulus*, a mirid bug from Australia and Fiji which feeds on the eggs of the sugar cane leaf-hopper and has now brought that pest under complete control.

1921—Four bruchid parasites from Texas.

1921—*Ischiogonus syagrii*, a parasite of the Australian fern weevil, introduced from Australia and has checked the spread of this fern weevil in the native forests.

1921–1922—*Pleistodontes froggatti* and *Pleistodontes imperialis*, caprifiers of *Ficus macrophylla* and *Ficus rubiginosa*, two Australian trees being used in reforesting projects in Hawaii.

1922—*Pseudaphycus utilis* from Mexico, as a parasite on the avocado mealybug, (*Pseudococcus nipae*) which it has now practically eliminated.

1923—*Lysiphlebus testaceipes* from California. An aphid parasite which has already become established and reared from four different aphids.

1923–1924—*Euplectrus platyhypenae* and *Archytas cirphiae* from Mexico as parasites of Armyworms. Already established and widely spread.

1925—*Anagyrus dactylopii* from Hong Kong as parasite of *Pseudococcus filamentosus*. Already established in several localities and promising well.

The introduction of beneficial insects, especially for the biological control of insect pests, is continually being carried on in Hawaii, being participated in by the entomologists of the several institutions there which are concerned with crop, garden, or other pests. In this paper are included the beneficial insects introduced from 1920 to 1925, inclusive.[1] They are treated chronologically.

Cyrtorhinus mundulus (Bred.) This little bug of the family Miridae, which is composed principally of plant-feeding bugs, was introduced from Queensland and Fiji in 1920 as an enemy to the sugar cane leafhopper (*Perkinsiella saccharicida* Kirk.), on account of its habit of piercing and sucking the leafhopper eggs. This bug was observed in the cane fields in Fiji by Muir in 1905, but its significance was not learned at that time. It was not till 1920, when in Queensland in search of additional leafhopper enemies, that he discovered the egg-sucking habit of *Cyrtorhinus*, and brought back with him to Honolulu the first colony of the bug. The main supply was secured by Pemberton later in the same year, from Fiji.

Up to this time, the sugar cane leafhopper had been very well controlled in most districts of Hawaii, chiefly by the egg-parasites introduced from Queensland, Fiji and Formosa in 1904, 1905 and 1916 respectively. However, there were a few of the sugar plantations that were still subject to severe outbreaks of the leafhopper. These have now all been relieved of leafhopper injury since the introduction and establishment of *Cyrtorhinus*. The bug was readily reared in cages both at the insectary and in field cages, which were carried on for about a year, and many hundreds of the bug reared for distribution. This work met with discouragement, however, for the bug seemed to disappear and fail to become established where liberated. The first recovery in the field was

[1]For a complete list of previously introduced beneficial insects in Hawaii, see Proc. Haw. Ent. Soc., Vol. 2, p. 299, 1923.

made in 1922 about a year and a half after the first liberation, and very soon the bug was found to be generally spread throughout all regions where there were any cane leafhoppers. From one small colony liberated on Kauai, in about half a year it was found to have spread to all plantations of the island. It reached the island of Maui without assistance and spread to all plantations. It was extensively liberated at one locality on Hawaii but soon spread from that to all plantations.

There are now no more injurious outbreaks of leafhopper. It seems to be completely controlled, only a few to be found anywhere in the cane, and usually quite difficult to find. If they do start to increase anywhere, *Cyrtorhinus* makes its appearance and increases also till the pest is checked. Then *Cyrtorhinus* also disappears simultaneously with the disappearance of the leafhopper, and remains scarce as the leafhopper is scarce. It seems to be dependent on leafhopper eggs for its existence. It does feed to some extent on the eggs of the corn leafhopper, but does not keep it sufficiently controlled as it does the cane leafhopper. It must be said to the credit of the egg-parasites that were first introduced and were instrumental in bringing about such great reduction of the leafhopper, they still exist in the cane fields, though scarce corresponding to the scarcity of the leafhopper, yet still having a share in the control of the pest.

Bruchid Parasites. Several parasites of bruchids were studied by Bridwell at Brownsville, Texas. Of these, *Lariophagus texanus* Cwfd., *Urosigalphus bruchi* Cwfd., *Glyptocolastes bruchivorus* Cwfd. and *Horismenus* sp. were brought to Honolulu by Willard in 1921 and have become established, and are a valuable addition to the previously introduced parasites in checking the ravages of four species of bruchids that infest the pods of the kiawe tree (*Prosopus juliflora*). This tree is very similar to the mesquite of the southwestern states, or probably the same species. It occupies large areas of arid land in the coast regions, much of which would be absolutely worthless but for this tree. Its pods are a valuable stock food, much relished by the cattle running in these regions. In certain seasons of the year, it is their chief food.

Fern Weevil Parasite. The Australian fern weevil (*Syagrius fulvitarsis* Pasc.) became introduced in Honolulu fern houses prior to 1904. It soon escaped to the adjacent forest regions and attacked some of the native ferns so badly as to nearly exterminate them. Later on it reached some of the other islands and threatened to spread to the entire natural forest where these ferns are an important part of the forest cover in watershed regions. The parasite, *Ischiogonus syagrii* Ful., was discovered by Pemberton, in Australia, in 1921, and introduced to Honolulu.

It quickly became established and has checked the weevil so that those kinds of ferns previously being extermined are on the recovery.

FIG WASPS. In forestry projects, certain species of *Ficus* have been selected to be used in an attempt to improve the watersheds in the mountains where the natural forests are on the decline. Two of these trees are *Ficus macrophylla* and *Ficus rubiginosa*, both Australian species. In order to facilitate their spread in Hawaiian forests, their respective caprifying insects were introduced: *Pleistodontes froggatti* Mayr, in 1921, for *Ficus macrophylla* and *Pleistodontes imperialis* Saund., in 1922, for *Ficus rubiginosa*. These fig-wasps soon became established on fruit-bearing trees in Honolulu and are ready to spread to their respective host trees that have been planted, when these come into bearing. The importance of this is that the figs of these trees will have seeds, and when eaten by birds, will be widely scattered in the mountain forests to regions impossible of access for artificial tree-planting.

CRICKET WASP. Incidental to other work in the Philippines, Williams discovered that the wasp, *Notogonidea luzonensis* Rohwer, was a parasite of field crickets. A few cocoons of the wasp were sent to Honolulu in 1922. The wasps that issued were liberated in cane at the Experiment Station. They became established and the first recovery was made in about a year. Soon after, it was found spread all over Oahu, and afterwards, without assistance, spread to the other islands, a reduction of the field cricket following in its wake. As the field cricket was not an important pest, no special importance is attached to the introduction of a parasite for it, but it is of interest in illustrating how readily a parasite may be introduced sometimes and become dispersed of itself without the assistance of the entomologists.

ENEMIES OF AVOCADO MEALYBUG. The mealybug, *Pseudococcus nipae* (Mask.) for many years such a bad pest on avocado, fig, banyan, guava, coconut and other plants, continued as one of the most troublesome orchard and garden pests, in spite of the fact that several introduced mealybug-feeding ladybeetles were working on it. In 1922, two more ladybeetles were introduced from Mexico, sent over from Vera Cruz, by Osborn. These were: *Hyperaspis silvestrii* Weise and *Curinus coeruleus* Muls. The first one proved the most efficient and was quite well distributed. What was far more efficient, however, was the little parasite, *Pseudaphycus utilis* Timb., also sent by Osborn from Vera Cruz. From a small beginning, this parasite became established and rapidly spread all over Oahu and proved 100 per cent efficient. Within two years the mealybug became so scarce that it was seldom seen except on guava in some outlying valleys, and now it is not met with at all on Oahu. These

made in 1922 about a year and a half after the first liberation, and very soon the bug was found to be generally spread throughout all regions where there were any cane leafhoppers. From one small colony liberated on Kauai, in about half a year it was found to have spread to all plantations of the island. It reached the island of Maui without assistance and spread to all plantations. It was extensively liberated at one locality on Hawaii but soon spread from that to all plantations.

There are now no more injurious outbreaks of leafhopper. It seems to be completely controlled, only a few to be found anywhere in the cane, and usually quite difficult to find. If they do start to increase anywhere, *Cyrtorhinus* makes its appearance and increases also till the pest is checked. Then *Cyrtorhinus* also disappears simultaneously with the disappearance of the leafhopper, and remains scarce as the leafhopper is scarce. It seems to be dependent on leafhopper eggs for its existence. It does feed to some extent on the eggs of the corn leafhopper, but does not keep it sufficiently controlled as it does the cane leafhopper. It must be said to the credit of the egg-parasites that were first introduced and were instrumental in bringing about such great reduction of the leafhopper, they still exist in the cane fields, though scarce corresponding to the scarcity of the leafhopper, yet still having a share in the control of the pest.

Bruchid Parasites. Several parasites of bruchids were studied by Bridwell at Brownsville, Texas. Of these, *Lariophagus texanus* Cwfd., *Urosigalphus bruchi* Cwfd., *Glyptocolastes bruchivorus* Cwfd. and *Horismenus* sp. were brought to Honolulu by Willard in 1921 and have become established, and are a valuable addition to the previously introduced parasites in checking the ravages of four species of bruchids that infest the pods of the kiawe tree (*Prosopus juliflora*). This tree is very similar to the mesquite of the southwestern states, or probably the same species. It occupies large areas of arid land in the coast regions, much of which would be absolutely worthless but for this tree. Its pods are a valuable stock food, much relished by the cattle running in these regions. In certain seasons of the year, it is their chief food.

Fern-Weevil Parasite. The Australian fern weevil (*Syagrius fulvitarsis* Pasc.) became introduced in Honolulu fern houses prior to 1904. It soon escaped to the adjacent forest regions and attacked some of the native ferns so badly as to nearly exterminate them. Later on it reached some of the other islands and threatened to spread to the entire natural forest where these ferns are an important part of the forest cover in watershed regions. The parasite, *Ischiogonus syagrii* Ful., was discovered by Pemberton, in Australia, in 1921, and introduced to Honolulu.

It quickly became established and has checked the weevil so that those kinds of ferns previously being extermined are on the recovery.

FIG WASPS. In forestry projects, certain species of *Ficus* have been selected to be used in an attempt to improve the watersheds in the mountains where the natural forests are on the decline. Two of these trees are *Ficus macrophylla* and *Ficus rubiginosa*, both Australian species. In order to facilitate their spread in Hawaiian forests, their respective caprifying insects were introduced: *Pleistodontes froggatti* Mayr, in 1921, for *Ficus macrophylla* and *Pleistodontes imperialis* Saund., in 1922, for *Ficus rubiginosa*. These fig-wasps soon became established on fruit-bearing trees in Honolulu and are ready to spread to their respective host trees that have been planted, when these come into bearing. The importance of this is that the figs of these trees will have seeds, and when eaten by birds, will be widely scattered in the mountain forests to regions impossible of access for artificial tree-planting.

CRICKET WASP. Incidental to other work in the Philippines, Williams discovered that the wasp, *Notogonidea luzonensis* Rohwer, was a parasite of field crickets. A few cocoons of the wasp were sent to Honolulu in 1922. The wasps that issued were liberated in cane at the Experiment Station. They became established and the first recovery was made in about a year. Soon after, it was found spread all over Oahu, and afterwards, without assistance, spread to the other islands, a reduction of the field cricket following in its wake. As the field cricket was not an important pest, no special importance is attached to the introduction of a parasite for it, but it is of interest in illustrating how readily a parasite may be introduced sometimes and become dispersed of itself without the assistance of the entomologists.

ENEMIES OF AVOCADO MEALYBUG. The mealybug, *Pseudococcus nipae* (Mask.) for many years such a bad pest on avocado, fig, banyan, guava, coconut and other plants, continued as one of the most troublesome orchard and garden pests, in spite of the fact that several introduced mealybug-feeding ladybeetles were working on it. In 1922, two more ladybeetles were introduced from Mexico, sent over from Vera Cruz, by Osborn. These were: *Hyperaspis silvestrii* Weise and *Curinus coeruleus* Muls. The first one proved the most efficient and was quite well distributed. What was far more efficient, however, was the little parasite, *Pseudaphycus utilis* Timb., also sent by Osborn from Vera Cruz. From a small beginning, this parasite became established and rapidly spread all over Oahu and proved 100 per cent efficient. Within two years the mealybug became so scarce that it was seldom seen except on guava in some outlying valleys, and now it is not met with at all on Oahu. These

conditions were repeated on the other islands a year or two later. The result is that *P. nipae* practically has been exterminated, or as near to extermination as ever is brought about by introduction of a parasite.

APHIS PARASITE. The braconid *Lysiphlebus testaceipes* (Cress.) was introduced from California by Timberlake in 1923. It readily became established, and has been recovered already from the following hosts: *Aphis sacchari* Zehnt., *Aphis maidis* Fitch., *Aphis medicaginis* Koch and *Aphis gossypii* Glover. While not significantly important as an aphis enemy, it is of value as an addition to the large number of aphis enemies previously introduced.

ARMYWORM PARASITES. The armyworms are pretty well controlled in the Hawaiian Islands by the mynah bird, introduced from India 60 years ago. A number of parasites were introduced from America about 30 years ago, which also help in control of army worms and cutworms, but in some parts of the islands there are still severe periodical outbreaks of these pests. Two additional parasites were introduced from Mexico by Osborn in 1923 and 1924.

Euplectrus platyhypenae Howard was sent from El Potrero, Vera Cruz in 1923. It proved very easy to rear in the insectary, and this has been kept up for three years, many thousands of the parasites being distributed to all regions of the islands. It became established quite readily on the islands of Hawaii, Maui and Molokai and widely dispersed. It is a valuable addition to the armyworm parasites already present. We do not yet know of its being established on Kauai and Oahu. There have not been continuous enough outbreaks of armyworms on these islands for it to maintain itself.

Archytas cirphiae Curran, a large tachinid, was sent by Osborn from Los Mochis, Sinaloa, in 1924. Only a very few flies issued from the material sent, and were liberated in a favorable place in Honolulu. No attempt was made to rear them. In about a year they were first recovered, and soon were found all over the island. Some attempts were made to collect and spread them to the other islands. This succeeded on Hawaii, but they reached Molokai and Maui of themselves before any were sent. We have not reared this fly yet from caterpillars collected in the field, but it must be of considerable benefit for it is often seen quite numerous where feeding on flowers or honeydew.

PARASITE OF *Pseudococcus filamentosus* Ckll. In 1925, Fullaway introduced *Anagyrus dactylopii* (Howard) from Hong Kong, where Dr. Silvestri pointed out to him its value as a special parasite on *Pseudococcus filamentosus* (Ckll.), which is a bad pest on citrus, cotton, hibiscus and other ornamental plants in Hawaii. The parasite has already be-

come established in several places in Honolulu and gives good hope that it will accomplish with this mealybug what *Pseudaphycus utilis* has done with the avocado mealybug.

NUTGRASS ENEMIES. A stem borer was introduced from the Philippines in 1925. It is a moth (*Bactra truculenta* Meyrick) whose larvae bore down through the stems of this troublesome grass (really a sedge, *Cyperus rotundus*) and eat the underground corms. In about a year this was known to have become established, but it is yet in doubt whether it will accomplish anything worthwhile in the destruction of nutgrass. The entomologists have been alive to the risks attached to the introduction of plant-feeding insects. The habits of this moth were studied in the Philippines before an attempt at introduction was made. It was also experimented with in quarantine in Honolulu before being liberated. It occurs on nutgrass in India also. Neither in India nor in the Philippines is it known to injure any crop or garden plant. The fact also that we have in Hawaii another species of *Bactra* (*straminea*) which confines its work to sedges (not including nutgrass) made it all the more appear to be safe to introduce the species from the Philippines. A small weevil with similar habits was also introduced, but so far it is not yet known to have become established.

BENEFICIAL IMMIGRANTS. I cannot refrain from making mention of three ophionids which came as natural immigrants to Hawaii and have shown themselves to be of economic value, for which the entomologists cannot claim any credit.

Cremastus hymeniae Viereck was first noted in Honolulu in 1910, by Marsh, who found it parasitizing the beet web-worm, *Hymenia fascialis* (Cramer). It was less common than some of the other parasites at the time, but later on it increased to be the most prevalent parasite on the larvae of leaf-roller moths. At the present time we have records of having reared it from 17 different hosts, of the families Pyralidae, Tortricidae, Carposinidae and Tineidae. It has spread of itself to all the other islands and is especially valuable in control of two important pests: the sugar cane leaf-roller, *Omiodes accepta* (Butl.) and the coconut leaf-roller, *Omiodes blackburni* (Butl.). We have a recent record of 60 per cent of the cane leafroller being parasitized by *Cremastus*, and one of 87 per cent of the coconut leaf-roller. For years the coconut trees have always had a very ragged appearance from the ravages of the leaf-rollers, but in several sections there has been a great improvement in the appearance of the leaves, in many places almost in perfect condition, and even in Honolulu for the past year there has been little injury by the leaf-roller. There are several parasites working on the coconut

leaf-roller, but it was not till *Cremastus* got to working on it that there seemed to be any degree of control. We have not learned yet where *Cremastus hymeniae* came from, as it was described from specimens from Honolulu. It has been the case with a number of our immigrant species that they were first described from Honolulu, and later on their native home was ascertained.

Casinaria infesta (Cresson) was first noticed in Honolulu early in 1921. Its first known host was also *Hymenia fascialis*, but it has been reared from 8 other pyralids, all native species in the mountain forests. It has spread to Kauai and Maui, but is not yet known on Hawaii. It cannot be considered of economic importance as its hosts are usually all scarce anyway, being kept in control by native parasites. However, when bringing in the larvae of these native pyralids for rearing, *Casinaria* more often issues from them than does any of the other parasites. This is an American parasite, occurring from Florida to Maryland and west to Kansas and Texas. Like many other recent immigrants, it is impossible to determine how this one reached Honolulu.

Hyposoter exiguae (Vierick) is a very recent immigrant. It was first observed in October, 1925, as a parasite on armyworms in a ranch near Honolulu. Since than it has been found at extreme points on Oahu, also on Maui and Hawaii. Its principal hosts have been the two armyworms, *Cirphis unipuncta* (Haw.) and *Spodoptera mauritia* (Boisd.). It was described from California where it was reared from *Laphygma exigua* (Hübn.), which is also one of its hosts here. Besides these it has already been reared from two other kinds of caterpillars, and it gives promise of becoming a valuable addition to our previous list of armyworm parasites. In one instance, 8 per cent of caterpillars collected were parasitized by this ophionid. Its cocoons on the grass would seem to indicate a much higher parasitism, however. Its habit of producing its cocoon on the vegetation where the parasitized caterpillar died, makes the presence of this parasite very easy to detect. It, no doubt, reached here from California in the cocoon stage on alfalfa hay or green vegetables.

MR. J. C. HAMLIN: Do important parasites in one country remain important when introduced into a new country?

MR. O. H. SWEZEY: Yes, but important ones often fail to become established, and unimportant ones often become important when introduced into a new country.

CHAIRMAN HERMS: The next paper is by M. Kamal.

A STUDY OF SOME HYMENOPTEROUS PARASITES OF APHIDOPHAGOUS SYRPHIDAE

By MOHAMMED KAMAL, *University of California, Riverside, Calif.*

ABSTRACT

This paper summarizes the result of investigations carried on by the writer in the last two years on the parasites of the aphis feeding Syrphidae of Southern California. The writer found that there are several species of hymenopterous parasites constituting the most important natural checks of these predacious flies. In certain seasons these parasites reproduced very rapidly at the expense of their hosts to the extent that the efficient work of these flies was greatly hampered, and consequently the aphids reproduced freely, causing serious damage to the infested alfalfa fields. No one species of these parasites can be regarded as exercising the most effective check on the flies, but there exists a sequence of several hymenopterous parasites persistently attacking the larval and pupal stages. Occasionally, one or the other of these enemies appear in such force as to be a serious menace to the syrphids. The seasons most favorable to parasite infestation are the spring and summer with the exception of the ichneumon, *Syrphoctonus* spp., whose percentage of parasitism for the various parasites has been as high as forty-five, over eighty per cent of which were the result of attacks by the ichneumon species during the fall and spring. In the summer, however, the *Diplazon laetatorius* and the chalcid parasites rank first in importance. Life history studies as well as the methods by which the parasitic larvae feed, respire, dispose of waste material will be briefly discussed. Important problems having economic or biologic bearings are dealt with in the text.

INTRODUCTION

The aphis feeding syrphids rank as high and under certain conditions higher than our common lady-bird beetles in their efficiency as plant lice enemies. On account, therefore, of the usefulness of these flies a study of their natural enemies is of unusual importance from an economic standpoint.

Practically nothing is known about the biology of these hymenopterous parasites; even the published rearings are very meagre and incomplete. These investigations have been carried on in the beneficial insect laboratories at the Citrus Experiment Station, Riverside, California. This study is concerned only with the aphis feeding syrphids of Southern California.

ACKNOWLEDGMENT

The writer wishes to express his appreciation to Professor Harry S. Smith and Mr. P. H. Timberlake for their valuable assistance. The latter has been generous in giving of his time to looking up the records which lead to the announcement of the new species herein treated.

THE INDIVIDUAL PARASITES

The individual parasites display a marked preference for particular hosts, with the exception of *Diplazon laetatorius* which attacks a long list of varied and even non-allied species.

Syrphoctonus maculifrons (Cr.)

DISTRIBUTION.—This species is widely distributed over Southern California from the coastal belt to the dry interior. It makes its appearance in the fall and increases until it reaches its maximum abundance in March, April and May.

MATING.—This takes place immediately after the emergence of the adult, especially in the presence of the host syrphid maggot which appears to serve as a stimulant to this process.

OVIPOSITION.—The excited female, whether being fertile or not, commences to oviposit in the victim as soon as they are confined together. She curls the tip of the abdomen between the hind legs and dashes towards the victim with the extended ovipositor, thrusting it far under the derm. In less than a minute an egg is laid. The posterodorsal part of the host is usually chosen as the suitable point for the attack, altho an extremely excited female does not hesitate to try any part of the body—even the head is mistakenly tried.

Oviposition in the host maggot may occur repeatedly by the same species or by other species. It has been observed that the females refused to oviposit in roughly handled larvae. The stage of the host preferred for oviposition is the second. The parasites show a decided preference for the larvae of certain species of syrphids.

SUPERPARASITISM.—This phenomenon has been found to occur in the laboratory as well as in the field. Generally, the fate of such parasitised specimens is death, which has been observed to occur even before the eggs hatch. Such a condition may be due to the mechanical irritation caused by the repeated puncturing of the integument, thus creating a physiological distrubance, or it may be due to a pathological effect caused by the secretion of a toxic substance injected with the eggs during the process of oviposition. The doomed larvae are easily detected by a pale yellowish colored zone at the caudal end followed by a dark excrement voided by the larva on its support. If such larvae are dissected, we find that the internal organs are undergoing complete disintegration.

LIFE HISTORY.—The adults have been kept alive in captivity as long as thirty-three days on honey droplets along the mid-rib of the lower surface of an oleander leaf. Separate fresh drops of water are continually added to supply drinking for the thirsty adults.

LIFE-CYCLE.—The eggs hatch in about three days. The total number of days spent in the larval stages varies according to the season. However, twenty to thirty days are considered to be the normal average. In summer the period drops to eighteen to twenty days.

The pupal period lasts from ten to fifteen days. Under favorable conditions, therefore, it would take seven weeks for an individual parasite to complete its life cycle.

The parasites spend their aestivation period as full grown larvae within the empty host puparia, ready to appear at the approach of cooler weather.

The imagoes issue thru holes with jagged edges cut at the inflated dorsal end of the puparium. The color of such parasitised puparium turns to dark red and the texture becomes leathery.

Syrphoctonus pacificus (Cr.)

DISTRIBUTION.—This endoparasitic species coincides in its seasonal occurrence in Southern California with the previous species, being more abundant in the spring and rare in summer.

LIFE CYCLE.—This species requires on the average about five to six weeks to complete one generation. The quiescent stage is spent in the last larva during the hot summer months, changing to the pupa as the fall approaches.

Homotropus decoratus (Cr.)

DISTRIBUTION.—This species abounds in Southern California wherever the host happens to be. From March to July seems to be the favorable seasonal occurrence.

About fifty per cent of the syrphid puparia collected by the writer from the Antelope Valley during April of this year gave rise in the rearing experiments to this species.

LIFE HISTORY.—Adults fed in captivity lived for forty days. The eggs hatched in about four days in the spring. The duration of the larval stages was fifteen days in June and July. The pupal stage lasted eight days. It takes, therefore, from twenty-four to twenty-eight days in late spring and summer to complete the life cycle from the egg to the adult.

HYBERNATION.—Altho this species occurs almost the year round, it seems to maintain a dormant period from the middle of October to the end of February when it begins to appear in very small numbers. The dormant stage is spent in the pupa. The emergence hole is rounded, with regular edges and is located in the dorso-cephalic region.

Homotropus humeralis (Prov.)

SEASONAL OCCURRENCE.—This is a rare species. Five is the number of specimens the writer has been able to rear in the last two years and all came from the Antelope Valley during March and April. It is presumable that the species occurs in other places in Southern California. In its life history this species coincides with the previous one.

Diplazon laetatorius (Fabr.)

SEASONAL OCCURRENCE.—This species is widely distributed all over Southern California, occurring the year round, being more common in late spring and summer.

HABITS AND BEHAVIOR.—In mating the male rides on the back of the female both facing the same direction. The process lasts a little longer than one minute. The excited female lays her eggs subcutaneously around the mid-gut region. The operation lasts for thirty seconds. The irritated victim tries to drive off its enemy by swinging the cephalic end of the body with the mandibles everted. A large supply of the salivary secretion is discharged and protects the victim by causing the entanglement of the parasites appendages.

It was amazing to make the same observation made by E. O. Kelly on the queer habits of oviposition. The female this time laid its eggs in the eggs of *Allograpta obliqua*. The parasite egg, which is sometimes longer than that of the host, lies curved as L-shape within, thus overcoming the difficulty of space accommodation. The parasite egg does not hatch until the host's embryo develops to the first larval stage. This strange habit of oviposition is by no mean widely practiced by this species. It is commonly observed that the parasites instead of ovipositing into the syrphid eggs, drill a hole with the ovipositor and then suck the contents of the egg, leaving behind the empty shells. In other words the adults work as predators on the syrphid eggs.

Oviposition takes place in all stages of the host but the ones which are preferred are the first and second larval stages. The caudo-dorsal end which is the most motionless part of the body affords a good target for the aim of the parasite. It is not uncommon to watch a female parasite dragged by the host maggot while being engaged in the process of oviposition.

LIFE HISTORY.—The eggs hatch in from three to four days. The duration of the larval period lasts twenty to twenty-five days. The pupal stage requires ten to twelve days. It takes the parasite, therefore, five weeks on the average under favorable conditions to complete the life cycle. The adult parasite makes its emergence through a large oval hole with regular edges and cut on the dorsum of the inflated body region of the puparium.

This parasite ranks second in importance among the syrphid parasites if taken collectively, and first among the summer-attacking forms, causing a serious reduction in the syrphid larvae amounting in some seasons during the summer months to almost forty per cent.

Diplazon orbitalis (Cr.)

SEASONAL OCCURRENCE.—This species occurs in Southern California only in the spring and summer and was reared from several localities near the coast or in the valley. It is another rare species and only a few specimens, amounting close to a dozen, were reared in the course of two years.

The life history and habits of this species are the same as in the previously mentioned allied species.

Pachyneuron allograptae Ash.

DISTRIBUTION.—This species is widely distributed all over the state of California from the north humid region of the coastal belt to the arid interior. It is prevalent from April to September. In the laboratory, however, this parasite was kept quite active and producing during the twelve months of the year.

MATING.—The ardor of the male for copulation is very keen and begins immediately after they issue out of the puparia. The males can be seen mating almost any time of the day. A once mated female is not even spared.

OVIPOSITION.—It takes the female approximately ten to fifteen minutes until she deposits her first egg and several hours to lay the full batch. The eggs are laid scattered or in small groups resting over the dorsum and sides of the pupa. A female can oviposit as long as she lives. When the female is occupied in the beginning of egg laying she becomes hateful and antagonistic but as soon as she becomes occupied in oviposition she quiets down. Two or more females may be seen to oviposit at the same time in the same pupa.

FEEDING AT THE EGG PUNCTURES.—The adult female parasites practice a peculiar habit of feeding at the puncture holes drilled by the ovipositor. A feeding tube as has been described by Faure does not seem to be present in this species. What is supposedly to be a feeding tube, I believe, is nothing but the dried viscid semi-fluid pupal juice which oozes out as it is extracted by the parasite's mandibles and later dries over the surface of the puparium.

LONGEVITY.—The ability with which these parasites breed freely under adverse conditions is very remarkable. In the summer of 1925 some of these insects survived a temperature of 112°F in the head house of the insectory and lived for a period of over four weeks without a drop of water and only on a diet of granulated honey.

LIFE HISTORY.—The eggs hatched from three to four days in June and July and after eight days in November. The total length of the

larval period is on the average from nine to twelve days. The pupal period lasts from six to eight days. It takes about nineteen to twenty-two days for an individual parasite to complete its life cycle. The emergence hole is small and round cut any where over the dorsum of the puparium. The total number appearing from one puparium varies from six to thirty or more. The number of individuals per pupa markedly affects the size of the issuing adults.

Bothriothorax californicus How.

SEASONAL OCCURRENCE.—This species was reared by the author from syrphid puparia collected from Milpitas in N. California and from various localities near the coast in S. California. As the parasite larva reaches maturity the host puparium begins to exhibit very marked inflations in the form of oval derm cells or integumental pockets, characteristic of attacks by the Bothriothorax species. The adults emerged thru small and circular holes with regular edges cut on the ventral surface near the cephalic end. Two or more holes close together or apart are occasionally observed in a single puparium.

Bothriothorax nigripes How.

OCCURRENCE IN S. CALIFORNIA.—This species was reared in April, May and June from syrphid larvae collected from the following localities, Whittier, Rivera and Hollywood.

Bothriothorax sp. nov.

This species corresponds to the preceding in its seasonal occurrence and habitat.

Syrphophagus sp. nov.

DISTRIBUTION.—This species was reared from syrphid puparia collected during May, June and July from Alhambra, Whittier, Pasadena, Anaheim and Riverside.

Conostigmus sp. nov.

SEASONAL OCCURRENCE.—This species was reared during April and May from syrphid pupae collected from Milpitas, Whittier, Los Angeles and Hollywood.

LIFE HISTORY.—The most striking feature in the life history of this species is its ability to spend a very long resting period in the last larval stage. The female oviposited on the 22nd of May 1925 and until the present date, June 9th, the larvae are still alive.

Conostigmus sp. nov.

This species was reared by the writer from syrphid material collected by him from San Diego on the 23rd of April 1926.

LIFE HISTORY.—The adults lived for 20 days in confinement. This species as well as the one before it are pupal parasites laying their eggs on the newly formed pupae. The eggs hatch in about two days and the primary larva starts feeding immediately by sucking the host juices thru the thin integument. The tissues are then undergoing the process of histolysis thus offering a continuous supply of highly digestible food. The internal organs are consumed at the end of the third larval stage and nothing is left but the hard or the chitinized parts of the pupa. The larval period lasts for about twenty-four days. Length of the pupal stage is from six to eight days.

SECONDARY PARASITES

Pachyneuron sp.

This hyperparasite was reared from syrphid puparia beginning on the fourth of March and lasting until the middle of May. It has been raised from specimens collected at Riverside and San Diego. This species resembles *Pachyneuron allograptae* in its habits and behavior and both coincide to a great extent in the duration of the various stages.

TABLE SHOWING THE SEASONAL OCCURRENCE OF THE PARASITES AND THEIR HOSTS

Parasites	Seasonal occurrence	Hosts
Syrphoctonus maculifrons	From Sept. to the end of May	*Scaeva pyrastri* *Syrphus nitens* *Eupeodes volucris*
Syrphoctonus pacificus	As above	*Eupeodes volucris* *Scaeva pyrastri* *Syrphus nitens* *Allograpta obliqua*
Homotropus decoratus	From March to July	*Eupeodes volucris* *Syrphus nitens* *Sphaerophoria cylindrica*
Homotropus humeralis	Same	*Scaeva pyrastri* *Eupeodes volucris* *Allograpta obliqua*
Diplazon laetatorius	From May to Sept.	*Syrphus nitens* *Syrphus americanus* *Sphaerophoria cylindrica* *Allograpta obliqua* *Allograpta fracta* *Baccha clavata* *Eupeodes volucris* *Mesogramma sp.* *Paragus tibialis*

Diplazon orbitalis	Spring and summer	*Eupeodes volucris* *Sphaerophoria cylindrica*
Pachyneuron allograptae	From April to October	*Allograpta obliqua* *Allograpta fracta* *Sphaerophoria cylindrica* *Syrphus nitens* *Syrphus opinator* *Scaeva pyrastri* *Eupeodes volucris*
Bothriothorax californicus	May–August	*Scaeva pyrastri* *Syrphus nitens* *Syrphus opinator*
Bothriothorax nigripes	April–June	*Eupeodes volucris*
Bothriothorax sp. nov.	May–July	*Syrphus opinator*
Syrphophogus sp. nov.	May–July	*Syrphus opinator* *Syrphus nitens*
Conostigmus sp. nov.	May	*Syrphus opinator* *Scaeva pyrastri*
Conostigmus sp. nov.	April–May	*Allograpta obliqua* *Sphaerophoria cylindrica*
Pachyneuron sp.	March to June	*Syrphoctonus maculifrons* *Diplazon laetatorius*

General Discussion

Location of the Parasitic Larvae Within the Host.—In the case of the ichneumonid parasites, the parasitic larva lies in the posterior half of the host, floating unattached in the body cavity of its victim. In the Chalcidoid parasites, however, the larvae do not necessarily confine their activities to definite regions of the host's body, but they scatter widely, attaching themselves to the surface of the body by their mandibles.

Effect of the Parasite on the Host.—The syrphid parasites lay their eggs, hatch and develop while the host is still in the active feeding stage. The parasitised maggot feeds and grows normally to maturity, forming a perfect puparium in the usual manner without revealing any symptom until the pupal stage. Upon dissecting such parasitised specimens one can easily observe the collapse and disorganization of the whole internal structures. If the host larva is attacked before the last ecdysis, it fails to reach its maturity and the parasite develops instead, but if the host is already far advanced in age, the parasite in most cases does not prevent it from reaching the adult stage. The constant drain of the growing parasite on the tissues of the host seems to be the cause of death; whether this or the toxic effect of some secretory elements, there is no doubt that death is the ultimate end of the host, which has been carefully spared and preserved by its enemy. Cannibalism is one of

the measures to which the *Syrphoctonus* parasites resort in order to relieve the situation of keen competition created by an over-abundance of parasitic larvae.

Respiration of the Parasitic Larva.—The process of respiration in the larva is carried on in various ways by the different species of parasites and sometimes these methods differ according to the successive stages of the same species. In the surface feeding parasite, e. g, *Pachyneuron* sp. and *Conostigma* sp. the respiratory system is present at the moment the first stage larva crawls out of its egg shell though not in a complete form. The process in the endophagous parasites, however is accounted for in a manner different from that in the previous group. The characteristic caudal appendage of the first stage suggests a respiratory function. Judging by the thinness of the cuticular body-covering of the early stages and by the fineness of the tracheids, it seems justifiable to assume that they function in the process of breathing. In the third stage, the larva develops its complete respiratory system and therefore the necessary supply of oxygen is drawn into the tracheal system thru the open spiracles.

Feeding Habits.—The growing internal parasitic larva with its simple alimentary canal requires easily digested food, which is absorbed by the mouth in the form of blood from the body cavity of the host. With further growth in the parasitic larva, we notice the gradual decrease in the host's tissues until it diminishes entirely at the close of the last larval stage. The mandibulatory feeding habit which has been condemned by some writers is here confirmed by the author. The mouth parts do not stand as the only agents in the process but other factors enter in as well. The attacked host draws on its stored food supply to replace the shortage of blood and lymph caused by the growing parasite.

Waste Products.—During the first and second larval stages the hind intestine remains closed and the waste is stored up in the malpighian tubes and at the end of the mid-gut until the feeding period has elapsed. In ichneumonid parasites mentioned the semi-fluid whitish excretion is disposed of immediately after the emergence of the adults. In the chalcidoid species, however, the waste products are deposited in the form of small bodies clustered over the mummy of the host. The material is eliminated at the time the last larva enters into the pupal or the prepupal stage.

Conclusion

In concluding this study, the writer feels justifiable in admitting the fact that, at the present, the anatomical structure of these parasitic

forms have been carefully verified, yet the functional significance of the structural adaptation to this mode of living both on the part of the parasite and on the host is still problematic.

CHAIRMAN HERMS: A paper not on the printed program will now be read by R. W. Doane.

THE REAPPEARANCE OF *HARMOLITA GRANDIS* AND *HARMOLITA VAGINICOLA* IN UTAH

By R. W. DOANE, *Stanford University*

ABSTRACT

The wheat straw worm and the wheat sheath worm, both of which were destructively abundant in Utah in 1914 and 1915, have been much less abundant during the past ten years, but in 1926 they again appeared in sufficient numbers to destroy some fields and to seriously affect others.

In 1914 and 1915 there were serious outbreaks of two species of *Harmolita* in Utah. At that time a great deal of damage was done to the wheat crops in some of the dry farm sections of that state, some of the fields not producing enough grain to pay for the cutting. The two species concerned were the wheat straw worm, *Harmolita grandis* Riley, and the wheat sheath worm, *H. vaginicola* Doane.

The wheat straw worm, as is well known, has two generations each year. The early spring generation, which is wingless, attacks the winter wheat, usually destroying the strongest young stems and often causing excessive stooling. The tillers that develop later may, under favorable conditions, develop good strong stems but the crop will mature somewhat later and this may be of considerable importance in a dry season. The second generation of adults appear about the time the wheat is in boot, sometimes a little earlier, and the females, which are winged, lay their eggs near one of the upper joints of the stems, again often selecting the strongest stems. The larvae feed on the inner walls of the stem causing it to become hardened and brittle and, if the head is not already well developed before the stem is attacked, the tiller may produce a poor, undeveloped head or no head at all. If the head is well developed before the attack, the effect is not as serious although the grains will not fill as well as they should.

The wheat sheath worm, or the wheat sheath-gall jointworm as Phillips has called it, has only one generation a year, the adults appearing somewhat earlier than the summer generation of the wheat straw worm. The female of this species lays her eggs, not in the stem of the

plant, but in the leaf sheath usually close to one of the joints. Phillips (U. S. Dept. Agric. Bull. 888) says that the eggs "are deposited in the tender leaf sheath surrounding the head." This, however, does not hold for Utah conditions, for we find as many, probably more, of the sheaths above the first or second joints infested, especially when the wheat is fairly well developed when it is attacked. An early infestation usually destroys the head or prevents its development. The leaf sheath becomes swollen and hard and the pressure on the stems prevents the sap from flowing and frequently causes grotesque deformities of the stem. A late infestation of some of the lower sheaths causes swelling and distortions and prevents the grain from filling in the head even if the head is formed before the stem is attacked.

In 1916 the damage done in the wheat fields in Utah by these pests, was less than in the two previous years. Since then the wheat straw worm has been more or less common every year but the losses due to its presence have not been as great as in 1914 and 1915. The wheat sheath worm has been very rare since 1916 in all the fields I have inspected and in the district where it was once most abundant I have not seen a specimen of the insect or its work for several years.

An inspection made early in May 1926, showed that much of the winter wheat was infested with the wheat straw worm and other inspections made late in May and early in June, showed that the larvae of the first generation of this insect had killed or seriously stunted from 40% to 70% of the first tillers in many of the fields. At the time of this last inspection the winged adults of the second generation were laying their eggs in the stems, some of which were already well headed.

An examination of representative stools taken to the laboratory showed that 15 to 25% of the stems were already infested with larvae that had come from the eggs of the second generation. This gives a total infestation due to the two generations of more than 80%. As the adults were still actively laying eggs the percentage of infestation will, of course, be found to be much higher when another examination is made during the last week in June. Of course this does not mean that 80% of the crop will be lost but some of the fields of volunteer wheat are so badly affected that they are now being plowed under and others will not be harvested. Still other fields in the same district will give very good yields because they were properly plowed and seeded, and were therefore in the best condition to sustain the attack.

In addition to the winged individuals found in the fields during the last week in May there were a few wingless forms which were crawling over the stems but I did not see any of them actually laying eggs. In

size and general appearance these wingless forms look just like the adults of the earlier spring generation and it is possible that they were simply belated individuals of that generation. I have never seen them before at this time of the year. A close examination showed that very small vestigial, metathoracic wings were present.

In fields in another district about 35% of the stems in the stools examined proved to be infested with the wheat sheath worm, so this species, too, has again become of considerable economic importance and we may look forward to still heavier infestations unless the stubble is burned or thoroughly turned under with the plow.

Morning Session, Friday June 18, 1926

The meeting was called to order at 9:30 A. M.

CHAIRMAN HERMS: We have a Symposium this morning on the subject, Petroleum oils in Insect Control. The first paper is by H. J. Quayle.

PETROLEUM OILS AS APPLIED TO CITRUS FRUITS

By H. J. QUAYLE, *Citrus Experiment Station, Riverside, California*

(Withdrawn for publication elsewhere)

CHAIRMAN HERMS: The next paper is by Mr. R. S. Woglum, a man of long experience in this line of investigation.

THE USE OF OIL SPRAY ON CITRUS TREES

By R. S. WOGLUM, *California Fruit Growers Exchange, Los Angeles, Calif.*

ABSTRACT

In recent years the red and black scales of citrus trees in California have, in certain districts, been developing increasing immunity to cyanide gas fumigation. One of the outgrowths has been the widespread use of sprays; those having an oil base have been the most successful. The California Fruit Growers Exchange, which handles three-fourths of the State's citrus crop, has been investigating this particular scale problem for several years. The observations of its Pest Control Department during the past season, which have covered the insect problems in all districts, might be summarized for oil sprays in part as follows:

1. The so-called quick breaking emulsions of white oil type, characterized by high viscosity and low volatility, and which leave an oil film on the tree for many weeks, has been the most effective type of spray against both armored and unarmored scales and the red spider where used in sufficient concentration. The concentration which assures dependable results appears to be not less than 1½ per cent actual oil in the case of scale insects.

2. Heavy applications of the white oil type of spray at concentrations approximating 1½ per cent actual oil appeared in many instances to produce certain undesirable effects on the plant itself, the extent of which was modified particularly by the environment of the plant, by the season of year, the variety of fruit and time of its maturity. Some of these effects were retarded coloration of fruit, reduced quality, lessened crop, drop of immature fruit and of tree ripe fruit, increase of aphis and possibly increased difficulty in controlling mealybug through the utilization of beneficial insects. At concentrations much lower than 1½ per cent actual oil these troubles largely disappeared in most districts. Scale kill, however, at lower concentrations was irregular.

3. In the case of the California red scale these white oil types of sprays give decidedly better scale kill on cutinized surfaces such as fruit and new wood than on the old wood which more readily absorbs the oil. The residual oil prevents the settling of larval scale for a considerable period on fruit and new wood.

4. The application of certain oil sprays to red scale followed within one or two weeks by a fumigation has been the most effective method of controlling the most resistant type of scale.

5. Some brands of oil emulsions are safely used with sulphur compounds under normal weather conditions whereas others are non-compatible with sulphur. The mixture of lime sulphur with certain oil sprays in the presence of calcium caseinate results in a spray which leaves little or no oily coating on the foliage, does not retard frui coloration, nor affect the set. Such combination sprays are among the most effective against immature unarmored scale but are of little value against the armored scales of citrus trees.

CHAIRMAN HERMS: I have long felt that a Department of Entomology needs a chemist. Our department, realizing this, took a trained entomologist and delegated him for a chemical training, to use in a study of insecticides. I take pleasure in calling on Mr. E. R. de Ong.

TECHNICAL ASPECTS OF PETROLEUM OILS AND OIL SPRAYS

By E. R. DEONG, *University of California*

ABSTRACT

A discussion of the tests by which the character of petroleum oil may be designated, with special reference to volatility and sulfonation in evaluating oils to be used for sprays.

The effect of petroleum oils of various specifications on insects and plants.

The relative value of different types of oil emulsions as insecticides.

Special attention is given to a discussion of the so-called "quick breaking" type of emulsion which was devised for use with very highly refined lubricating oils which are too expensive for general use unless their efficiency as insecticides is increased beyond that found in stable emulsions made from this type of oil. This system of emulsification is recommended only for oils that are practically harmless to the plant if applied pure. The use of very small amounts of emulsifiers permits the oil to separate quickly from the emulsion stage, thus making the oil more effective and decreases the amount of oil in the runoff.

The difficulties and dangers attending the use of petroleum oil during many years have had a very limiting influence on it. During the last two years, however, there has been a remarkable increase in the use of oil sprays due to a number of reasons: first, in a number of places unsatisfactory results from the use of sulfur compounds for the control of San Jose scale and as a summer spray for red spider, and in southern California the failure of hydrocyanic acid gas to kill the so-called resistant scale insects; second, the general adoption of the light lubricating oil sold under somewhat definite specifications in place of crude oil or the volatile kerosenes,—a distinct advance in oil usage; third, the discovery of the value of oil refining by the use of sulfuric acid or sulfur dioxide, as a means of reducing danger to the plant both as a foliage and dormant spray. The correlation between safety to the plant and the refinery process was shown in 1915 by Gray and deOng but the data have just been published (1). The use of casein and other emulsifiers not affected by "hard water" is also overcoming the danger of broken emulsions where soap is used as the emulsifier.

The result of these various steps has been to place oil sprays on a sounder basis than they have ever been before. This does not mean that all the difficulties have been solved but it does show that the adoption of definite specifications for insecticidal oils is as necessary as in the purchase of oil for any other purpose. The injury which has resulted from the use of modern types of oil sprays is more often due to unfavorable conditions such as excessive heat at the time of application, drouth, either from a lack of soil moisture or drying winds, or an imperfect emulsion rather than to any inherent factor in the oil itself. Continued study of oils as insecticides will, no doubt, give a knowledge of the subject which will make the use of these much safer than it is at present.

Much progress has been made in recent years on the study of the physical characters of oils which might have a bearing on their toxicity. Shafer (2) first studied the action of oil on insects while Moore (3) and Freeborn (4) have shown the value of volatility as a standard specification. Ackerman (5) first brought lubricating oil into general use and through his published specifications makes possible the comparison of the oil he used with others. Melander, Spuler and Green (6) discuss the value of viscosity and distillation history, stressing the latter character as the most important.

Characters Used in Specifying Oils

We now have in use, it will be seen, a number of characteristics, principally physical, for identifying uniform grades of oil. None of

these tests alone gives sufficient information regarding the character of an oil but a combination of two or more tests should always be used. A brief description of the attributes is appended.

DENSITY.—"The density or specific gravity of an oil (commonly expressed in degrees Baume or in late technical papers as A. P. I.) indicates to some extent the nature of the oil, whether thick or thin." (1) Its use is retained mainly to distinguish between the volatile kerosene and the relatively slow evaporating lubricating oil. "Petroleum oils of the same density may vary widely in volatility, viscosity and other characteristics. Lighter and heavier oils may be compounded to obtain any density between that of the original oils. Even unblended oils of the same density but from different sources may have different characteristics."

FLASH POINT.—The lowest temperature to which an oil must be heated to give off inflammable vapor in sufficient quantity to produce a combustible mixture,—this is an indication of volatile constituents and of their relative volatility. A low flash point in a viscous oil may indicate the blending of a light and a heavy oil.

DISTILLATION.—The fractional distillation of an oil at varying temperatures indicates the "quantity and density of the fractions distilling between ranges of temperature at stated intervals." In this way the oils of different densities, viscosities and volatilities are obtained. This process has been shown by Moore and Graham (3) and Melander, Spuler and Green (6) to be very important in defining the action of an oil. It is sometimes taken as the indicator of volatility and it is very intimately associated with this characteristic, but since distillation usually begins between 200 and 300° C. and above and ranges as high as 400° at which time decomposition or cracking begins (under vacuum it is possible to distill at 100° C. lower) it does not seem especially significant in field work except as an indicator of the proportions of volatile and non-volatile oils.

VOLATILITY.—This is one of the most important characteristics of an oil. It is a basic distinction between a kerosene and a lubricant. The former evaporates so quickly that it is ineffective against most insect eggs and resistant scale insects. The latter persists in the form of a film on the leaf surface or in the intracellular spaces for weeks or even months and acts as a repellent or a toxic agent during this time. A test is now being tried on the loss in weight of oils used in a controlled temperature similar to field ranges as an indicator of volatility suitable for spray oils. The correlation between this and insecticidal qualities has not been completed.

VISCOSITY.—The viscosity or freedom of motion of the molecules of an oil, often spoken of as "body" or "fluidity" is an important property in the selection of a lubricating oil. This property is often expressed as the rate of flow through a definite orifice at a standard temperature in comparison with that of water as the standard. Viscosity has frequently been used as an indicator for volatility, since it is a standard test for all oils, but there are many conditions under which the two attributes are not uniform. Oils from a similar source, distilled at the same range of temperature, will be quite uniform in viscosity but the refinery process of agitation with sulfuric acid or sulfur dioxide to remove unsaturated hydrocarbons will change the viscosity enormously while the volatility and flash point remain constant. For example, an oil with an original viscosity of 430 seconds Saybolt, when treated with fuming sulfuric acid to make a highly refined petrolatum type of oil changes to a viscosity of 250 seconds, and an oil with an original viscosity of 130 to 140 seconds, when completely refined, has changed to 80, but the flash point has remained constant in both instances.

Blending oils of widely varying physical characteristics will also change the viscosity and may produce a similar flash point, e. g.:

430 viscosity, 350 to 365° flash point + 25% kerosene = 80 viscosity, 170° flash point.

106 viscosity, 315 to 330° flash point + 25% kerosene = 55 viscosity, 170° flash point.

SULFONATION.—Petroleum oils are refined by the use of sulfuric acid or in more recent practice, that of liquid sulfur dioxide. The raw distillate is agitated with the acid until the latter unites chemically with the unsaturated hydrocarbons, i. e., aromatics and cracked oils to form sulfonates. The saturated hydrocarbons, naphthenes and paraffins react very slightly with the acid and when agitation is completed rise to the top of the tank thus separating from the acid sludge. Treatment with various amounts of acids produces oils of varying degrees of refinement. Out of this practice has grown a laboratory test which is one of the measures of the safety of an oil to be used on trees either dormant or active; this is known as the sulfonation test, (1), (7) i. e., the percentage of oil which will combine with sulfuric acid by agitation. The oils which by refinery process contain the smallest amounts of unsaturated hydrocarbons are, so far as we now know, the safest for use in spraying trees. The dangerous elements in an oil are in practical refining removed only by treating with sulfuric acid or liquid sulfur dioxide. Filtration may remove the color and leave a lubricating oil almost perfectly clear and

white and yet it would be dangerous to use on foliage at summer temperatures. Chemical treatment of oils does remove the dangerous materials to a very large extent which will be shown by agitating the oils in fuming sulfuric acid. The residue which will not combine with sulfuric acid is said to be "unsulfonatable." An oil containing a very small percentage of materials which will combine with acid is safer than one which has a high percentage of sulfonatable materials.

TABLE I. SPECIFICATIONS[1] OF OILS TESTED.

No.	Gravity[2] degrees A. P. I.	Flash point[3]	Fire point	Viscosity[4] in seconds at 100°F.	Color	Sulfur per cent	Unsolfonated residue of oil per cent	Acidity in mg. of KOH per gm. of oil
1	19.2°	305°F	—	105–108	—	.7	51	1.5
2	21.3	310	350°F.	99	—	.65	52	1
3	22.5	310	350	96	6[5]	.6	56	.6
4	22.7	320	360	107	2.5–	.6	60	.4
4x	22.7	320	360	100–110	1.5	.6	62	.03
5[8]	29.8	320	360	106	25[6]	.006	98	.0
5x[8]	28–31	280	—	70–80	25[6]	0.15	98	.0
6	20.5	360	—	330–340	3	.6	58	.2
				Kerosenes				
1a	35.9	124CT[7]	—	375	—	—	81	
2a	41	83CT	125	320	25[6]	.016	82	
3a	41.3	113CT	135	345	25[6]	.010	93	
4a	43.3	143CT	175	400	25[6]	.006	98	

[1]The pour point on all oils used was below zero Fahrenheit.

[2]The A. P. I. gravity table is so similar to the Baume gravity table that for all practical purposes they may be considered identical for lubricating oils.

[3]Cleveland open cup.

[4]Determined by the Saybolt Universal Viscosimeter. The viscosity of kerosene fractions is measured by the Saybolt "Thermoviscosimeter" which bears no relation to the lubricating oil viscosimeter.

[5]A. S. T. M. standards.

[6]A. S. T.M. standard for kerosene by Saybolt chronometer.

[7]Closed Tagliabue Tester.

[8]This increase (from about 22.5° A. P. I. to 29.8°) is the result of the excessive treatment with acid. It follows that gravity alone is no criterion since this property of finished white oil is practically identical with that of some raw distillates such as gas oil, though obviously viscosity and flash (*and* molecular weight) are much higher. As a general rule the saturated hydrocarbons are much lighter in gravity than either olefines or aromatics, e. g., Heptane (N) Gravity 75°, Tolnene Gravity 32° A. P. I.

OXIDATION.—The saturated hydrocarbons which are almost the only constituents of the highly refined white oils, are not active chemically but when exposed in thin films to the action of oxygen and sunlight certainly undergo some chemical changes, but of this phenomenon

little is known except that there is an increase in acidity. This subject is being studied further and may shed considerable light on the reaction of oils on foliage.

Effect of Oils on Insects

The insecticidal tests(8)to date have been made largely on the red scale, *Chrysomphalus aurantii* Mask., this being a very resistant form of scale insect and an excellent subject for microscopic study. The insect when removed from the scale shows the tracheal system under high power very clearly without preliminary clearing. The penetration and movement or position of the different oils in the tracheal system could then be determined accurately. Much credit is due Mr. Hugh Knight, formerly of the University of California Citrus Experiment Station, and more recently Mr. J. C. Chamberlin of the same Station for the technic of this

Table II. Effect of Oil of Varying Degrees of Refinement on French Prunes

Oil	Concentration	Remarks (Applied May 28 and 29 Read June 3 Maximum temperature 100°F.)
I	4%	20% defoliation, 2% dead area, foliage mottled, light yellow
I	2%	No defoliation, slight yellowing
II	4%	20% defoliation, 2% dead area, mottled
II	2%	5% defoliation, mottled
III	4%	4% defoliation, mottled
III	2%	2% defoliation
IV	*4%	Normal
IV	*2%	Normal
V	2%	Normal
Ia	4%	Normal
Ia	2%	Normal
IIa	4%	Normal
IIa	2%	Normal
IIIa	4%	Normal
IIIa	2%	Normal
IVa	4%	Normal
IVa	2%	Normal

*Later applications of this oil caused some foliage injury.

study. This method of examination showed that when a drop of volatile oil, e. g., kerosene, was placed on the scale insect it penetrated throughout the tracheal system but was frequently expelled almost as rapidly, apparently by the efforts of the insect. A highly refined kerosene containing but two or three per cent of unsaturated hydrocarbons seemed to have very slight effect on the insect. Any volatile oil containing a large amount of unsaturated hydrocarbons seemed to pass

throughout the entire body cavity, dissolving first the fat bodies and finally even the entire cellular structure of the interior part of the body.

Lubricating oils of the non-volatile highly refined type penetrated but a short distance into the main tracheal trunks but there remained indefinitely apparently killing by suffocation. A high content of unsaturated hydrocarbons hastened materially the time of death.

Effect of Oils on Plants

The data in Table II show strikingly the relation between oils containing a high amount of unsaturated hydrocarbons and those of a high degree of refinement. The kerosene group is seen to be almost harmless to prune trees but on account of its volatility it is of little value as an insecticide. The specifications for the oils used will be found in Table I.

Besides the acute effect of oils manifested by defoliation, twig and fruit injury, there is an apparent disturbance of physiological processes of the tree and fruit. This is manifested by a slight delay in the ripening of fruit and forced dropping of tree-ripe lemons and Valencia oranges on citrus trees. A similar disturbance of functioning has been noted in French prunes; this may be shown in a few days' delay in the ripening of fruit or for very late applications, a loss in weight of the dried fruit. These difficulties are especially noticeable with the less volatile oils which give a film of long permanence. This may possibly be overcome

Table III.

Spray Date	Maximum and Minimum Temperature	Remarks
11/17	64–38	Bloom 95% out, slightly retarded*
12/2	58–47	Past full bloom, 5% of petals dropped
12/15	55–30	Normal development, 35% of petals dropped
12/28	39–34	Slight stimulation, 50% of petals dropped
1/13	36–32	Decided stimulation, 80% of petals dropped
2/8	59–42	Slight retardation, 10% of petals dropped
2/17	58–37	Retardation of bloom and foliage
3/2	74–47	Leaf buds just opening when sprayed. One year old wood killed back four to eight inches. Sprouting along main limbs
3/16	66–41	Leaf clusters expanded when sprayed. Leaves showed brown spots, petals browned. Fifty per cent of fruit spurs on one tree failed to leaf out, not affected on second tree. One year old wood killed back followed by sprouting on the main limbs. One year old wood which was not in leaf was killed back while that which was leaved out was less badly injured

*An unsprayed block in another part of the orchard showed 40% of the petals off which was considered normal.

by the use of the non-volatile oils early in the season and oils of greater volatility applied late in the development of the crop if necessary.

A series of oils ranging from kerosene upwards to a lubricating oil of a viscosity of 70 seconds Saybolt were applied to French prunes eight days before picking to determine the effect on the drying ratio as indicating a delay in the ripening of the fruit or at least a disturbance in the amounts of solids present. The drying ratio of the unsprayed fruit was 3:03 to 1, that of kerosene 3:14 to 1, light lubricating oil, viscosity 50 seconds Saybolt, 3:55 to 1, and a lubricating oil of viscosity 70, 3:70 to 1. These oils were all highly refined so that the viscosity test alone is largely definitive.

This experiment was on a very limited scale but indicates a serious disturbance of the normal plant functions, probably due to a delay in ripening. Applications of oil sprays to immature fruit did not show such striking changes in the fruit when mature.

Dormant Sprays on Deciduous Trees.—A series of sprays was made on French prune trees to determine the effect of oil at varying degrees of dormancy. Every two weeks from November 15 to March15, two trees were sprayed and the effect noted by the time of blooming. This work was repeated the second year but since the results were similar, the readings from one season only will be given.

Oil used: Gravity 25 A. P. I., Flash Point 310° F., Viscosity 96 seconds Saybolt, Unsulfonatable Value of 56 per cent; applied as a 6 per cent emulsion using a very small amount of calcium caseinate as the emulsifier. Condition of trees noted March 19, 1926.

Retardation is shown in Table III as a result of the November spraying but to a less extent than occurred with this spray the previous winter. December sprays are almost normal in both years while stimulation occurs from the last of December through January. In both series retardation is shown in February sprays and from then on. There is a decided difference in the two series in the amount of injury, the first series showing none and the last one severe twig killing in March applications. The maximum temperature was ten degrees higher in 1925–26 than in 1924–25 for the spray the first of March but no different for the Spray of March 16.

The greatest difference in the results of the experiments for the two years was the injury resulting from late sprays during the second season, while there was no apparent injury to any of the trees in the first year's work. The only suggestion that can be offered to explain this difference is that the trees used in the second year's experiments had been injured by drouth and red spider the previous summer, to

such a degree that they showed some dead wood when the spray was applied. Apparently the condition of the tree during the six months prior to spraying had much to do with its susceptibility. This idea was strengthened by the results of greenhouse experiments where potted prune trees in soil with moisture of 32 per cent and others of 12 per cent (wilting point) were sprayed with 6 per cent emulsions and then placed for three days in freezing temperatures, and others at a maximum range of 60° to 80° F. In all cases the trees in the dry soil suffered much more severely than those in moist soils.

Oil Emulsions

Much progress has been made in recent years by the chemists and physicists in the study of the fundamental principles of emulsions. Since this work has a direct bearing on our problems, I have taken the liberty of reviewing a few points that are most closely related to the forms of emulsion I wish to discuss. The petroleum oils with which we have been working are not, as is well known, considered sufficiently safe to use alone on plants and hence have been diluted with a material which would act as a carrier. Water lends itself readily for this purpose but these two liquids being immiscible, it is necessary to use chemical or mechanical means of dispersing the oil in droplets and of stabilizing the mixture sufficiently long to permit application to the trees. There are two types of oil emulsions, oil-in-water in which the oil is dispersed as globules in the water, and water-in-oil in which the reverse system is found. Insecticidal emulsions are largely the former type although they may approach the water-in-oil type.

Oil droplets when dispersed in water have a tendency to coalesce whenever they touch unless separated by some other substance. This material is either of a colloidal nature or finely divided solids. Donnan (9) showed that increasing amounts of sodium hydroxide lowered the interfacial tension, due to the formation of soap and suggested that emulsification was due to the formation of a layer of soap at the oil-water intersurface. The sodium salts of the higher fatty acids were adsorbed at the separatory boundary between the oil and water thus forming a distinct film which prevented the coalescence of droplets. Bancroft (10) stated that this film was a separate phase both from the oil and water and might even consist of a very finely divided solid. Langmuir (11) and Harkins, Davies and Clark (12) substantiate the previous theories of a film surrounding the droplet of oil and suggest that the molecules of this film are oriented in such a way that the group soluble or wetted in oil is turned in that direction, and that which has an affinity for water is turned in that

TABLE IV. RELATION BETWEEN MORTALITY AND THE PROPORTION OF EMULSIFIER USED.[8]

	Spray	Per cent	Count Alive	Count Dead	Kill* %	Oil in runoff** %	Remarks
A	White Oil Light Calcium Casein Mixture	2 2	200	65	67.7	2.4	One lemon dry which accounts for relatively high mortality. Many young.
B	White Oil Light Calcium Casein Mixture	2 1	200	99	50.5	2.3	Many young
C	White Oil Light Calcium Casein Mixture	2 .5	200	77	61.7	2.2	Many young
D	White Oil Light Calcium Casein Mixture	2 .25	200	15	92.5	1.8	Slightly greasy, first appearance of oil film
E	White Oil Light Calcium Casein Mixture	2 .125	200	0	100	1.5	
F	White Oil Light Calcium Casein Mixture	2 .0625	300	0	100	1.3	Approximate† ratio of casein recommended by m'f'r
½F	White Oil Light Calcium Casein Mixture		200	0	99.5		
G	White Oil Light Calcium Casein Mixture	2 .031	250	0	100	.6	Well developed oil film
½G	White Oil Light Calcium Casein Mixture		200	2	99		No live young
H	White Oil Calcium Casein Mixture	2 .0156	200	0	100	.5	No posthumous young
I	White Oil Calcium Casein Mixture	2 .0078	275	0	100	.34	No posthumous young
½I	White Oil Calcium Casein Mixture		200	0	100		No posthumous young
	Check—No treatment		200	93	53.5		One lemon quite dry

*Natural mortality count made Nov. 29, 1924 (same day as test) equals 49.7%.
**From a 2% emulsion made with varying amounts of emulsifier.
†One half pound of calcium casein mixture per 100 gallons of spray.

direction. In other words, the film might be bent in either direction, in one phase the film encloses oil and makes an oil-in-water emulsion, in the other phase the invert or perverse form of emulsion is formed of water-in-oil. The latter form has been shown by Tinkle, Draper and Hilderbrand (13) to be dependent upon the type of emulsifier.

An emulsion with oil as the external phase would theoretically be more effective than where water is the external phase. But since these emulsions cannot be diluted in water and are usually of a tough or gummy nature, they do not lend themselves readily to orchard practice. The problem of bringing the active insecticide, oil, immediately in contact with the insect instead of having it locked up inside a tough film surrounded by water was overcome to a large extent by the quick breaking type of emulsion which allows the water to separate out almost immediately and run off, leaving a film of almost pure oil on the leaf surface. This brings the active insecticide, oil, in direct contact with the insect instead of water or a colloidal solution neither of which is an insecticide. This increases the insecticidal action to such an extent, as will be shown later, that the almost prohibitive cost for the stable type of emulsion made from white lubricating oils is reduced to a point where they are economically practical for orchard spraying. The amount of oil lost in the run-off is reduced, as shown in Table IV, from 2 per cent in the original emulsion (where 5 grams of emulsifier are used to 2.5 grams of oil) to .34 per cent, with the emulsifier reduced to .0078 grams and the amount of oil remaining constant (8).

The emulsions were made with a white lubricating oil (No. 5) of the so-called "neutral" type. The emulsifier used was a mixture of powdered casein and hydrated lime, the proportions being one to four. Varying proportions of soap as the emulsifier gave similar results, hence the data are not given.

A typical formula used is as follows:

5.75 cc. (5 gm.) oil
244.125 cc. water
.125 gm. calcium casein mixture

The calcium casein mixture is dissolved in a small amount of water to which the oil is added wholly or in part and the entire amount forced through a small spray pump which forms an emulsion that can be used very satisfactorily in an ordinary power sprayer. Such an emulsion "layers" very quickly but on starting the agitator is quickly formed again into a homogeneous mixture.

The quick-breaking type of emulsion should be used only with oils

that are known to be almost harmless to the plant at the time the material should be applied. The use of oils of a moderate degree of refinement is hazardous to trees unless quite dormant. A larger proportion of oil is left on the surface, than with a stable emulsion, and also the thickness of the oil film may be slightly increased by covering two or more times, certain parts or all of a tree at one spraying operation. Hence, unless an oil is used which is almost neutral in its reaction to the tree, damage may result. However, the quick breaking emulsion was devised primarily to increase the activity of the oil, which by the refinery process has lost some of its insecticidal qualities, and thus make the use of highly refined and necessarily expensive oils economically practical for the orchardist even where the margin of profit is small. If used with this understanding of its function, the efficiency and value of our oil sprays may be increased.

The criticism is sometimes made of quick-breaking emulsions that they are more dangerous to the tree than stable emulsions, but this does not take into consideration the true function of this type of emulsion, which is to apply oil in practically a pure condition, implying that the oil shall be harmless to the tree whether active or dormant. In fact, the next step in progress is probably the application of pure oil directly to the tree without a carrier or emulsifier which, of course, requires a decided advance in our present knowledge of oils and their reaction on plants.

Literature Cited

1. Gray, Geo. P. and E. R. deOng
1926. California petroleum insecticides. Inds. and Eng. Chem. 18: 175–180, Feb.
2. Schafer, G. D.
1911. How contact insecticides kill. Mich. Agr. Exp. Sta. Tech. Bul. No. 11.
3. Moore, Wm. and S. A. Graham
1918. A study of the toxicity of kerosene. Jr. Econ. Ent. 11: 70–75, Feb.
4. Freeborn, S. B. and R. F. Atsatt
1918. The effects of petroleum oils on mosquito larvae. Jr. Econ. Ent. 11: 299–307, June.
5. Ackerman, A. J.
1923. Preliminary report on control of San Jose scale with lubricating oil emulsion. U.S.D.A. Dept. Circ. 263, June.
6. Melander, A. L., A. Spuler and E. L. Green
1926. Investigations on oil sprays. Wash. Agr. Exp. Sta. Bul. No. 197.
7. deOng, E. R.
1927. Experimental studies in the use of petroleum oils as insecticides on citrus and deciduous trees. Amer. Petroleum Inst. Bul 7: 191–196, April.
8. deOng, E. R., Hugh Knight and J. C. Chamberlin
1926. Hilgardia, California Agr. Exp. St. (in press).

9. DONNAN, F. G.
1899. Ueber die natur der seifenemulsion. Zeik. Phys. Chem. 31:42.
10. BANCROFT, W. D.
1915. Theory of emulsification. Jr. Phys. Chem. 19:275.
11. LANGMUIR, I.
1917. Constitution and fundamental properties of solids and liquids. Jr. Amer. Chem. Soc. 39: 1848.
12. HARKINS, W. D., E. C. H. DAVIES and G. L. CLARK.
1917. Orientation of molecules in the surface of liquids. Ibid. 39:541.
13. TINKLE, P., H. D. DRAPER and J. H. HILDERBRAND.
1923. The theory of emulsification. Jr. Amer. Chem. Soc. 45:2780.

The question of oil sprays was discussed at length by the above speakers and E. J. Newcomer, F. B. Herbert, T. D. Urbahns and Don C. Mote.

CHAIRMAN HERMS: Proceeding with our regular program, the next paper is by Don C. Mote.

THE NATURAL "CLEANING UP" HABIT OF INSECTS

By DON C. MOTE, JOSEPH WILCOX and EARL G. DAVIS, *Oregon Agricultural Experiment Station, Corvallis, Oregon*

ABSTRACT

This paper calls attention to the habit of certain insects of passing their legs and antennae between their mouth parts and the removing of powdered materials in this manner. This habit of the insects, the writers have termed the natural "cleaning up" habit of certain insects. A brief review of some of the literature on this subject is given. An attempt is made to distinguish *cleanliness* from *irritation* as the cause of the stimulation of this action. The following insects have been stimulated to this natural "cleaning up" habit in our experiments: *Diabrotica soror, Blatella germanica, Forficula auricularia, Syneta albida,* and *Criocerus asparagi.* Several of the following dusts have stimulated the "cleaning up" with each of the above insects: Sodium fluoride, calcium arsenate, lead arsenate, sodium fluosilicate, wheat flour, and powdered milk sugar. The methods used in the experiments are briefly explained.

The use of dust materials in the control of insects has seen a rapid advance within the last ten years. The improvements in the dusts themselves and the many advantages of dusting over spraying has established dusting as a method of insect control that is here to stay. The writers in this article wish to call attention to the habit of certain insects of passing their legs and antennae between their mouth parts to remove powdered materials and which they will term the natural "cleaning up" habit of certain insects. It is believed that this habit is a natural tendency on the part of the insect, and that this phenomenon should be added to the list of advantages of dusting over spraying.

Various writers in the past few years, as well as some earlier writers, have recognized this habit of insects, but have not clearly defined it as a natural "cleaning up" habit of the insects.

Shafer (1) was the first investigator who to our knowledge demonstrated that the American cockroach cleaned powdered sodium fluoride and borax from its body, legs and antennae with its mouth, thus in the "cleaning up" operation ingesting enough of the material to constitute a fatal dose. Marcovitch (2, 3 & 4) demonstrated that the Mexican Bean Beetle ingested powdered sodium and calcium fluosilicate in the same way and also controlled a number of other insects with these materials. Ingram (5) has demonstrated that blister beetles can be controlled with sodium fluosilicate and that the beetle ingests the material by "raking its irritated feet through its mouth." Wilcox (6) has shown that the Western Spotted Cucumber beetle ingests powdered lead arsenate in the same manner.

This habit of insects of removing powdered materials from their body, legs, and antennae with their mouth parts as reported in the above and other articles, has been attributed to what has been termed "irritation." It seems then that in this connection that the word irritation should be defined especially as contrasted with what the writers will term cleanliness.

Irritation as used in this connection is some sort of chemical reaction between the finely powdered materials and the weaker or membraneous parts of the insect's body.

Cleanliness is a natural tendency on the part of the insect to clean any powdered material from the body. There may be an irritation in a sense but it is physical not chemical in that the powder interferes with the proper functioning of the body parts. To theorize for a comparison, it would be in the same sense that a layer of powder or dirt on the fingers and hands of man would interfere with the sense of touch, but it would not irritate unless there was a chemical reaction as would happen with powdered caustic soda.

Shafer (1) is the only investigator who has demonstrated that powdered sodium fluoride and borax produce a chemical reaction with the membraneous parts of the body of the cockroach. In our experiments we have not attempted to demonstrate whether the powders used irritate or not. However, we have used powders other than the fluorides and fluosilicates and have been able to stimulate the "cleaning up" action.

Wilcox (6) mentioned that *Diabrotica soror* Leconte was observed cleaning particles of dirt from its tarsi with its mandibles. More re-

cently we have observed this insect "cleaning up" on undusted plants in the field and have stimulated the "cleaning up" process with common wheat flour in the laboratory.

The German Cockroach, *Blatella germanica* L. reacted in the same manner with sodium fluoride, calcium arsenate, lead arsenate, sodium fluosilicate and powdered milk sugar. The above powders are arranged in the order in which the roaches were killed in the shortest time.

The European Earwig, *Forficula auricularia* L. was stimulated to pass its fore tibia and tarsi, and antennae between its mandibles by the following powders; sodium fluoride, lead arsenate, calcium arsenate, sodium fluosilicate, and milk sugar. In a cage experiment in which the earwigs were confined on cabbage plants dusted with the above materials, the earwigs were killed in the shortest time in the above order.

The Syneta Leaf Beetle, *Syneta albida* Leconte and the Asparagus Beetle, *Criocerus asparagi* L. have been stimulated to the "cleaning up" action by the following materials: lead arsenate, calcium arsenate, sodium fluosilicate and sodium fluoride. It was not possible to check accurately on the rapidity by which the various dusts killed the beetles in these experiments because of the very short time that it took all the dusts to kill the beetles. In cage experiments, all the dusts killed the Syneta Leaf Beetle in a shorter time than did a spray of lead arsenate 4–100.

The method used in the above experiments was to confine the insects in a petri dish in each of which a pinch of powder was placed. The time taken to kill the insects and the manner of ingesting the powders could be observed in such experiments. In the cage experiments, twigs or plants were dusted and a number of insects (from 10 to 100) were confined in cages on the plants. The per cent of insects killed at the end of various periods was calculated and only enough observations were made so as to check on the manner of ingesting the powder.

The writers feel that there is great possibility in the use of this natural "cleaning up" habit of insects in their control and present this preliminary paper with a hope of stimulating experimental work by others on this subject.

LITERATURE CITED

1. SHAFER, G. D., (1915)—"III. How Contact Insecticides Kill." Mich. Agri. Exp. Sta. Tech. Bull. No. 21, pp. 51–55.
2. MARCOVITCH, S., (1924)—"New Insecticides for the Mexican Bean Beetles and Other Insects." Tenn. Agri. Exp. Sta. Bull. No. 131.
3. ———(1925)—"Non-Arsenicals for Chewing Insects." Journal Ec. Ent. Vol. 18, pp. 122–128.

4. ———(1926)—"Supplementary Investigations of the Fluosilicates as Insecticides." Tenn. Agri. Exp. Sta. Bull. 134.
5. INGRAM, J. W., (1925)—"Sodium Fluosilicates as a Control For Blister Beetles on Soybeans in Southwestern Louisiana." Reprint from November Issue, The Rice Journal, New Orleans.
6. WILCOX, J., (1926)—"A Suggestion as To How Phytophagous Insects May Ingest Powdered Poison." Journal Ec. Ent. Vol. 19, p. 189.

CHAIRMAN HERMS: The next paper will be read by J. F. Lamiman.

ORCHARD SANITATION AS A FACTOR IN CODLING MOTH CONTROL

By J. F. LAMIMAN, *University of California*

(Paper not received)

CHAIRMAN HERMS: The next paper is by Ralph H. Smith.

THE EFFICACY OF LEAD ARSENATE SPRAYING IN CODLING MOTH CONTROL

By RALPH H. SMITH, *University of California, Riverside, California*

(Paper not received)

CHAIRMAN HERMS: Although not on the program it gives me pleasure to announce that we have a paper by Mr. Geo. M. List.

SOME POSSIBILITIES IN CODLING MOTH CONTROL

By GEORGE M. LIST, *Fort Collins, Colo.*

ABSTRACT

There is a general demand for other methods of control of the codling moth, *Carpocapsa pomonella*, to supplement that of spraying. Under some conditions spraying alone is not proving satisfactory. The use of bands, orchard sanitation, and picking wormy fruit should be made more use of.

Ovicides show possibilities as a means of reducing the number of stings. Oils have proven the most efficient ovicides.

It is possible to trap large numbers of adult codling moth. A fermenting sweetened apple juice is proving to be a valuable attractant. The traps can be used as a means of determining the insect development in an orchard for the establishment of spray dates.

The codling moth has received a great deal of attention from the entomologists of all fruit growing sections for many years. Volumes have been written on its life history and control. Much of this liter-

ature has been very definite in recommendations and positive that this or that practice was the secret of success. Many statements have been based on assumptions upon very meager work or upon trials that have been made under conditions that have not given a thorough test of the method. However, much has been learned. Spraying practices, machinery and insecticides have been greatly improved. Those of even ten years ago are crude. But in spite of all this, there never has been as great concern over the control of the insect nor as great a demand for improvements and additional methods of control. This is awakening in the entomologists the feeling that possibly our methods are not as perfect as have been supposed, and some have even dared or have been forced to think along other lines than those handed down as the orthodox methods.

Certain sections in Colorado have long been notorious for their heavy codling moth infestation and in the minds of many the failure to reach a perfect control has been a reflection upon the growers. The Colorado entomologists have on many occasions had to bear with the smile that has come to our coworkers of other sections upon a recital of our experiences. But I think it is safe to say that the thoroughness in the codling moth work is usually in direct proportion to the degree of infestation and difficulty encountered in controlling the insect. Our great range of conditions that gives us the localities where even the "one-spray method" seems ideal and not many miles away another one where control seems impossible has given us good conditions under which to observe this.

In certain sections the conditions have gradually been getting worse, from a time when good crops were produced with from three to five sprays, until now when the insect is a very important limiting factor. In fact, many trees are being pulled because of failure to control the codling moth or the heavy expense involved in securing anything like satisfactory control. There seems to be at least an approach of these conditions in many other fruit growing sections as evidenced by the fact that there is scarcely a fruit-growing section of the entire country from which we have not received within the last two years, either from growers or entomologists, a call for help, many thinking that our experience might be of value to them. All have expressed the hope that we might give some suggestions of other methods to supplement that of spraying.

There is a growing feeling that spraying alone is far from being a perfect means of control. At the best, it will give only a partial control and the degree of failure while not so noticeable in many localities, is so

great that under conditions most favorable for the insect, economic failure may result.

Our bitter experiences forced us to this conclusion several years ago, and the urgent demand for help from our growers has encouraged some interest in other phases of control. It is my object here to mention some of these only briefly.

In our heavily infested sections the growers are told that a careful use of bands is as important as spraying. The wisdom of this is shown by the fact that on carefully scraped trees it has been possible to catch as high as 45 per cent of all larvae maturing on the trees.

The importance of orchard and packing house sanitation can not be overemphasized. The wormiest portions of an orchard are invariably those about the packing sheds and places where cull fruits have accumulated. A relief from this condition as well as a careful thinning of the apples before the first brood worms mature, and a destruction of all wormy fruits should hardly be considered in the realm of possibilities for control, but from the standpoint of the grower they are, since they are not, as a rule, generally accepted as a part of the control campaign.

Dr. C. P. Gillette and the writer started some preliminary tests of ovicides in 1915. Since that time Mr. J. L. Hoerner, W. P. Yetter, Jr., and the writer have made laboratory tests involving 26,688 eggs, and extensive field tests. While we are not in position to make any definite recommendations, we feel that this method of attack is worthy of additional careful study.

In all sections of any considerable degree of infestation the greatest loss results from the so-called "stings." The stung apple or pear is usually as complete a loss from the standpoint of profit as the wormy one, and such fruits may outnumber the wormy from three to twenty times. Methods of spraying to completely avoid such conditions have never been demonstrated under maximum codling moth conditions.

If an efficient and practical ovicide that can be incorporated with certain of the poison applications can be developed, its value for certain conditions cannot be doubted.

In the 15th Annual Report of the State Entomologist of Colorado, Mr. J. L. Hoerner and the writer reported on 411 laboratory tests made during 1921–22–23, involving 14 materials representing the more promising types, and in the 16th Annual Report Mr. Yetter reported some similar tests. It will be sufficient here to give only a brief summary of the results.

Black Leaf 40, ranging in strength from 1 to 600, to 1 to 1000, both with and without calcium caseinate and soap spreaders, showed little

efficiency. The efficiency was somewhat greater as the eggs used approached hatching when treated. This probably explains the promising results reported by Lovett[1] on his test of a limited number of eggs.

Lime sulphur used in summer strengths gave little or no kill. The various soaps proved of little or no value when used in strengths that would be practical.

Throughout the work the oil sprays have shown the greatest promise. It has not been difficult to get good kills with surprisingly low percentages of oil with both proprietary spray oils and emulsions made from the heavy oils including the white and lubricating types, but the difficulty has been to find a material that is not injurious to fruit and foliage. After seeing many cases of severe foliage and fruit injury in orchards where the growers have used different oils, we are convinced that all dormant spray oils are quite unsafe to use as summer sprays when high temperature occurs. But it seems very possible that a spray oil can be developed that will retain its ovicidal qualities and still be safe to use. The so-called "summer" oils only recently placed on the market seem to be a great step in this direction and show possibilities worthy of careful consideration. The great danger is that manufacturers will claim too much for their products before they have been carefully tested or that orchardists in their anxiety for some relief will place too much confidence in a method that should be considered in the experimental stage.

During the season of 1921 Mr. J. H. Newton, working at Paonia, and Mr. W. P. Yetter, Jr., at Grand Junction, became interested in the possibility of trapping the adult moths. During the course of their work with various materials, Mr. Newton discovered the attractiveness of fermenting sweetened apple juice. Since then Mr. Yetter has further developed the use of this method until the "hootch" trap as it is called by the growers, shows real promise. Mr. Yetter has also tested a large series of aromatic chemicals with the result that more than 20 show a definite attractiveness, but with none of them at this time showing more promise than the fermenting liquid. The possibility of this method of attack is indicated by the fact that 34 traps operated by Mr. Yetter in a carefully sprayed orchard during 1925 caught 3,655 moths, 2,218, or approximately 61 per cent of which were females heavy with eggs. The value of such a catch cannot be denied.

We have long been in need of an accurate and simple method of determining the codling moth development in the orchards in order to

[1]Lovett, A. L., Nicotine Sulphate an effective ovicide for codling moth eggs. JOURNAL ECONOMIC ENTOMOLOGY, Vol. II, No. 1, Feb., pp. 149–150.

intelligently time the applications of spray. Such a method appears to be offered in the moth traps. A definite knowledge of when moths are flying in the orchards is of far more value than a band or temperature record and much simpler and possibly more accurate than the time-taking breeding cage records.

MR. E. J. NEWCOMER: Codling moth bands are now manufactured by a tent and awning company of Yakima and sold to orchardists.

A light trap is being advertised, which has an electric light in the center of a framework of charged wires. So far its practicability has not been demonstrated.

Adjournment.

Afternoon Session, Friday June 18, 1926

The meeting was called to order at 1:30 P. M.

CHAIRMAN HERMS: The first paper on the program this afternoon is by Messrs Packard and Campbell.

THE PEA APHID AS AN ALFALFA PEST IN CALIFORNIA

By C. M. PACKARD and ROY E. CAMPBELL, *Associate Entomologists, Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

The recent outbreaks of pea aphid, *Illinoia pisi* Kalt., in southern California have followed mild winters with low rainfall, which allowed the survival of many viviparous females and their rapid multiplication with the advent of spring. The first growth of alfalfa in infested fields was destroyed, the second growth weakened, and weeds enabled to grow and mature in abundance as a result of the retardation of the alfalfa. The epidemics ended with the coming of hot weather, due to development of insect enemies, failure of food supply and shade, and direct killing effect of heat and low humidity. A number of artificial control methods were tested. Those of practical value were cultural practices for the purpose of eradicating winter alfalfa growth and attendant overwintering aphids in the fields, the use of burning machines, contact sprays or calcium cyanide for newly sprouted alfalfa, and early cutting. Those of no value were brush dragging, the Dudley aphidozer, and cultivation after active growth had commenced in the spring. Introduction of *Hippodamia convergens* lady-beetles was tried with negative though suggestive results.

CONDITIONS FAVORABLE TO OUTBREAK

During the past few years alfalfa in various parts of southern California has been badly injured in late winter or early spring by the pea aphid (*Illinoia pisi* Kalt.). These outbreaks have followed winters characterized by mild temperatures and low rainfall, the shortage of

rainfall usually continuing through the spring months. These conditions allowed some growth of alfalfa throughout most of the winter, there having been usually enough moisture to provide for this growth. The favorable weather conditions and presence of suitable food permitted the survival and some reproduction of viviparous females. At the same time the prevailing temperatures and humidity were not conducive to the development of fungous diseases and insect enemies of the aphids.

Character of Injury

With the advent of warmer weather, therefore, the aphids were in a position to multiply more rapidly than the food supply increased, and as a result the first crop developed into aphids instead of alfalfa. Not only was the first growth of alfalfa destroyed but the vigor of the immediately succeeding growth was reduced. Moreover, while the alfalfa was being held back by the aphids, foxtail grass and other weeds were able to develop in much more than normal abundance, the infestations thus indirectly causing a serious aggravation of the perennial problem of weed control.

Natural Control

The natural control of these heavy spring infestations has also depended on weather conditions. When warm spring weather arrived the syrphids and coccinellids rapidly multiplied in the fields so that in a few weeks they were important factors in checking the aphids. So far as our observations go, the insect enemies of this aphid have never become abundant early enough to prevent serious injury to the first crop, and it is questionable if they alone have ever effectually brought a heavy infestation on alfalfa under control.

Two other factors have been largely responsible for reducing the aphid population to the point where their insect enemies could cope with them. The first factor is the failure of the food supply. The aphids drain the sap from the green growth so that it curls up, turns yellow, and usually dies completely. New growth is slow in starting and insufficient to supply food and protection for the hordes of aphids. They therefore begin to migrate, both on foot and on the wing. New infestations in hitherto uninfested fields often develop at this time, but these usually do not become serious because of the abundance of coccinellids and syrphids and because the growth is so far along that the aphids can not materially check it before cutting time.

The second and perhaps most important factor in reducing the aphids to normal numbers is the occurrence of occasional hot, dry days. Ex-

treme heat and low humidity result directly in the death of great numbers of aphids in fields where there is little green vegetation to protect them from the direct rays of the sun and reflected heat from the ground. Little piles containing hundreds of aphids killed in this way were present under the plants last spring in the Antelope Valley immediately following the unusual heat and low humidity of March 15. This condition was observed in a number of fields where the alfalfa had been severely stunted by the aphids, but not in fields where the ground was well shaded by green alfalfa.

A combination of three factors, therefore, all brought into action by the arrival of warm, dry weather, has been chiefly responsible for the termination of the recent spring epidemics of the pea aphis in alfalfa, namely, the rapid increase of insect enemies, the failure of food supply and shade, and the direct killing effect of heat and drought. Unfortunately these agencies become effective too late in the spring to prevent serious injury to the first crop of alfalfa.

Fungous diseases, however, must not be omitted from a consideration of the natural agencies affecting aphid outbreaks. Several instances have been observed where *Entomophthora aphidis* and *Empusa* sp. have been chiefly responsible for the speedy elimination of *Illinoia pisi* as an alfalfa pest. Here again weather conditions may be the dominant factor. Such was the case in Los Angeles County in 1924. During the long periods of comparatively warm but dry weather in late winter of that year the aphids multiplied enormously. Then in early March warm rains and general humidity prevailed for several days. These conditions were evidently ideal for fungous development because an epidemic of *Entomophthora aphidis* spread rapidly among the aphids and greatly reduced their numbers.

A moist environment produced by abundant irrigation and rapid transpiration from the alfalfa also favors development of the fungi. Irrigation was evidently indirectly responsible for the prevalence of diseased aphids in some fields in 1924. Again in 1926 several fields were seen in the Antelope Valley where early and frequent irrigation had induced the development of so much Empusa among the aphids that the incipient infestations never became of consequence. These observations form the basis of one of the control recommendations to be mentioned below.

Artificial Control

The information already secured relative to artificial control of the pea aphid on alfalfa seems of sufficient value to warrant presentation at

this time. Methods of control may be divided into cultural or preventive measures, and remedial measures.

Cultural or Preventive Methods

Considerable evidence has been obtained to show that cultural operations can be utilized practically and effectively to prevent spring outbreaks of the aphid without reducing the annual yield or quality of the alfalfa. The main principle underlying cultural control is the prevention or elimination of all growth in the fields during the winter. The presence of some green alfalfa during most of the winter is necessary to the survival and reproduction of viviparous females, and the rapidity of increase of the aphids in the spring depends on the number of these females surviving the winter in the alfalfa. Experience has shown that the eradication of all growth from the fields during the winter will do away with the aphids.

Histories were secured last spring of the cultural operations throughout the previous fall and winter in 18 uninfested and 9 infested fields in the Antelope Valley. An analysis of the information thus obtained, in addition to the miscellaneous observations of the last four years, has led to the tentative conclusion that spring outbreaks may be effectively prevented by the following practices.

1. Stop irrigation early in the fall, (by October 1 in the Antelope Valley.)
2. Make the last cutting after growth has stopped.
3. Remove all growth during the winter (a) by heavy pasturing, or (b) by heavy cultivation.
4. Determine the time of the first spring irrigation by the condition of the field. *For dormant fields*, delay irrigation until warm growing weather; then irrigate plentifully and often, to stimulate rapid growth of alfalfa and fungous diseases of the aphids. *For fields naturally starting growth early, or for young alfalfa needing early irrigation*, irrigate early and often, to stimulate rapid growth and to favor the spread of fungous diseases of the aphids.

One or more of these operations were practiced in every one of the uninjured fields observed. On the other hand there was much evidence to show that some green growth persisted most of the previous winter in the injured fields. These operations make conditions very unfavorable for the multiplication of the aphids in the fall and their survival during the winter. At the same time these practices tend to increase the yield, improve the quality, and reduce the weediness of the fields. Further-

more, cultural control does not involve the expense and trouble of any radical remedial measure such as the use of burning machines.

Objections have been offered to some of these practices, especially winter pasturing and cultivating. Upon careful consideration and observation, however, none of these objections appear to be serious and they seem to be outweighed by the benefits secured. In addition, the number of effective cultural control methods at hand allow the farmer some latitude in meeting the special conditions in his fields and for indulging his personal prejudices. From our observation winter pasturing, if properly done, seems to be beneficial and profitable rather than otherwise, irrespective of its virtues as an aphid control.

The following objections are frequently offered to winter pasturing:

(1) Packing of the ground. This objection is probably valid for heavy land if pastured when too wet, but soil packing can be largely prevented by removing stock during wet periods and cultivating lightly in early spring if necessary. It would probably be much cheaper to pasture the fields clean and feed hay during wet periods than it would be to suffer an aphid outbreak in the spring or go to the expense of using a burning machine.

(2) Trampling down of check-ridges and breaking of concrete standpipes. Observations in pastured fields and discussion with farmers indicate such damage to be slight and easily repaired.

(3) Injury to the stand of alfalfa. No actual evidence could be obtained from farmers or by observation to support this objection.

(4) Favor weeds. The clean stands of alfalfa last spring in several fields which had been heavily pastured the previous winter certainly contradicted this objection. Some farmers say that cattle will leave the foxtail grass and eat only the alfalfa, but when forced to it by hunger the cattle ate the grass off clean in the fields observed. Also it is said that sheep will eat green foxtail fully as readily as alfalfa.

(5) Introduction of weeds. All common weeds are already present in the fields, and if due care is used not to bring in stock, especially sheep, from localities where new weeds, such as puncture vine, are known to occur, this objection is unimportant.

Heavy winter cultivation is often objected to on the ground of injury to the stand. This objection is probably valid in colder regions of the country and in some seasons in California. Our observations in the Antelope Valley in 1926, however, indicated this operation to be more of a benefit than a detriment to the crop, regardless of its effect on the abundance of aphids, particularly if a cultivator was used instead of a disc. A few alfalfa crowns were broken off but these appeared to be

rather lifeless, or weakened plants with brittle roots which, perhaps might better be replaced anyhow. Furthermore, several instances were observed where satisfactory stands of new plants were secured without difficulty by scattering a little seed in the thin spots when conditions were favorable for germination and growth of seedling alfalfa. It therefore seemed evident that what few plants were killed by the heavy cultivation could be replaced.

Remedial Measures[1]

We now come to a consideration of the remedial operations available for use when serious spring injury to the alfalfa is actually in progress. This phase of the problem has been attacked from a number of angles. The following methods promise to be of practical value:

1. Burning Over the Fields. This method of control originated among the Antelope Valley farmers and has given the best promise of practical success. Effective burning, however, requires the use of expensive special machinery. Simply burning over such portions of a field as will carry a fire is ineffective for obvious reasons. This year's experience has shown that all vegetation must be removed from the entire field and adjacent ditch banks, fencerows, roadways, and farmyards, if reinfestation is to be effectually prevented. The alfalfa plants apparently were not injured by the burning and immediately afterwards put out an abundance of vigorous new growth.

In order to burn fields over completely, Ernst and Stirniman tried spraying fuel oil of different grades on the field and then igniting it. With the right kind of fuel, considerable dry plant growth present throughout the field, and a strong breeze to carry the fire, this procedure was very successful. This type of burning, however, proved unreliable and often inapplicable. The reasons for this were insufficient dry growth in many infested fields, too much green growth often present which would not burn even when covered with oil, the necessity for the right kind of a wind, and unburned spots left to act as sources of reinfestation. It was found necessary to use in the neighborhood of 100 gallons of fuel an acre even under favorable conditions, making the cost of fuel

---

[1]The following agencies have cooperated with the authors in the experiments: (1) The Antelope Valley Farm Bureau and numerous individual farmers; (2) the Agricultural Extension Service of Los Angeles County, through F. H. Ernst; (3) the Division of Agricultural Engineering of the University of California, through E. J. Stirniman; (4) the Antelope Valley Union High School, Farm Mechanics Department, through E. S. Smith; and (5) the American Cyanamid Co., through Fred Record.

alone about $5 an acre. In view of the expense and uncertainty of this method of burning it is not considered generally practical.

The use of burning machines has greater possibilities and is advancing beyond the experimental stage. The aphids were controlled successfully by this means on several hundred acres in the Antelope Valley this year at a total cost of $4 to $5 an acre. The burning also was very beneficial in reducing weeds. Many farmers think a maximum expenditure of $4 or $5 an acre is warranted if the first crop can be saved from the aphids thereby, especially if the weed nuisance can be abated at the same time.

The extensive burning just mentioned was done with a commercially made burning machine. Several experimental machines were built by farmers and investigators. The general arrangement of all these machines was the same, consisting of a low-wheeled carriage with a horizontal feed pipe across the back to which is fastened a series of burners so placed as to project their flames downward and backward against the ground. The fuel is supplied to the burners under pressure from a tank and air compressor on the burner carriage, or from an ordinary spray rig in front of the burning machine.

All the machines but one were equipped with burners of the generative type in which the fuel is vaporized by heat in coils of pipe before it reaches the nozzle, so that it is ejected under pressure and burned as a gas. In all variations of this type of burner much trouble was experienced with clogging by internal deposits of carbon, especially with the lower grades of fuel oil. The other type of machine was patterned after the burner used in the European corn borer clean-up work. In this mahine the fuel is not vaporized inside the burner by heat but instead is forced as a liquid under high pressure through spray nozzles especially constructed to withstand high temperatures. The fine spray thus formed burns at a distance of several inches from the nozzles and there is no opportunity for the deposition of carbon in them. Mr. L. H. Worthley, in charge of the European corn borer control work, states in correspondence that no trouble with carbon deposits in these nozzles is experienced except where previous clogging by sediment in the fuel has occurred. The flame produced by this burner was of considerable greater volume than that of the generative burners.

The chief advantages of the spray type of burner are its simplicity of construction, its freedom from carbon clogging, its ability to burn cheaper fuel, and the fact that since more of the combustion takes place on the ground and vegetation than is the case with the generative burners the heat is more evenly distributed, persistent, and penetrating.

Although it consumed more fuel than the generative burners it would burn cheaper oil and do thorough work at a faster pace, making it possible to cover the ground more rapidly and to dispense with the second burning which was found necessary to complete destruction of the vegetation with the generative burners. The present indications are that modifications of the spray type of burning machine, such as the addition of a hood or wind-shields, will make it the best yet developed for the purpose.

2. Spraying. The results of a number of spraying experiments in which contact insecticides and power or traction sprayers were used were unfavorable except on very small alfalfa. The main difficulty was in hitting a sufficient percentage of the aphids. The application of 250 to 300 gallons of spray an acre at a high pressure, at least 250 pounds, produced a fairly satisfactory mortality on short alfalfa and newly sprouted seedling alfalfa. Fish-oil soap and distillate emulsion were the best sprays tested.[8] The effectiveness of nicotine was largely nullified by low temperatures and windy conditions. Spraying would be of practical value in preventing the destruction of newly seeded alfalfa by aphids coming in from other fields.

3. Fumigating With Calcium Cyanide. Two fields of small seedling alfalfa were saved from destruction by aphids last spring through the use of granular calcium cyanide. This material was applied with a special wheelbarrow seeder at the rate of 20 pounds an acre. Approximately 95 per cent of the aphids were killed where the material was applied under favorable atmospheric conditions, with very little injury to the plants. Granular calcium cyanide, therefore, is thought to have a distinct place in eradicating infestations on alfalfa which is too young to be burned. Although more expensive, cyaniding appears to be more practicable than spraying for this type of infestation. The cost of material for treatment would be from $3 to $5 an acre, which is allowable when the trouble and expense of reseeding are considered.

The practicability of using calcium cyanide on well established alfalfa has not yet been settled. Some evidence was secured indicating that 25 pounds of granular cyanide an acre applied with a duster followed by a 40-foot canvas trailer would kill practically all the aphids. Many experiments with cyanide dust, however, have produced generally unfavorable results even where a canvas trailer was used, since many aphids recovered after having been stupefied temporarily by the gas.

4. Early Cutting. Several instances have been noted in which the disappearance of the aphids apparently was distinctly hastened by clipping the alfalfa as short as possible soon after warm weather had

arrived in earnest. This operation made conditions unfavorable for them by reducing their food supply and protective shade, causing the death of many by exposure to heat, the migration of others, and the concentration of the remainder on what little green food was left so that they were more accessible to their natural enemies. In several cases, also, removal of the stunted alfalfa seemed to stimulate a quick new growth. Early, close cutting and removal of the hay, followed by irrigation not less than a week or ten days later, appears to be advisable where the alfalfa is too far advanced to permit of burning and the occurrence of hot dry weather is likely.

Some Remedial Measures of Doubtful Value

Brush dragging was given a fairly thorough trial in 1924, some plots being treated as many as five times. The small mortality of aphids resulting from this treatment was surprising, and it seemed clear that brush dragging was of no value.

Trials of the Dudley aphidozer were made in 1925. This machine caught large quantities of aphids but left too great a number on the alfalfa. Its adaptability to practical use in alfalfa is doubtful because so many of the aphids are well down in the crowns or on the ground where the machine can not catch them.

Cultivation of the fields, after growth is well under way and infestation is already heavy, seems to be of no value, judging from several instances which have been observed. It was evidently impossible to reduce either the green growth or the aphids sufficiently by this means.

The addition of insecticides to irrigation water has often been suggested, but the impossibility of completely submerging a high percentage of the infested plants in an entire field seems to discount this suggestion without the necessity of a trial.

The value of lady-beetle introduction is always a live subject and deserving of consideration. One fairly good test of this type of control was made this year. Approximately a million adults of *Hippodamia convergens* Guer. were taken by automobile directly to an Antelope Valley field from their hibernating places in the mountains and liberated on March 11, as early in the spring as the weather seemed warm enough to promote their activity. They were scattered broadcast over about 5 acres of heavily infested alfalfa in a 100-acre field. There was practically no mortality en route and the beetles began feeding and mating at once. Within twelve days, however, few of them were left in the original area where liberated, and larvae and pupae of this species which could not have been their progeny had become abundant. Moreover, by March

24, too soon after the liberation for progeny of the introduced beetles to have become effective, the aphid infestation had been much decreased by other factors. It was clear, therefore, that the introduced beetles had no significant part in the reduction of the aphids, and that the native beetles must have become active some little time before the introduction was made.

Although not conclusive, this experiment is perhaps an indication of the uselessness of spring liberations. Two other points are also brought out: First, direct introduction of the beetles from their hibernating places to the infested fields was made with practically no mortality, as compared with the high mortality in previous liberations of beetles held for some time in cold storage; and second, the beetles thus liberated began feeding and mating at once. The observations also suggest the possibility that earlier liberations, perhaps at the time the native beetles first become active, might be of more assistance in checking spring infestations.

Several other pertinent questions suggest themselves regarding which no published information seems to be available. We need to know more about the habits of the native beetles, the relative value of fall, winter, and spring introductions, and the practicability of securing *Hippodamia convergens* in sufficient quantities to provide for the large acreage involved.

Conclusion

In summarizing the present status of the alfalfa aphid problem it may be said that investigations thus far have brought about a better understanding of the conditions influencing the abundance of aphids in the spring, have pointed the way to a number of promising methods of prevention and control, have proved the inefficiency of several other control methods, and perhaps have reopened the question of biological control by means of lady-beetle introduction.

Chairman Herms: The next paper is by Joseph Wilcox, and will be read by Mr. Mote.

THE LESSER BULB FLY, *EUMERUS STRIGATUS* FALLEN, IN OREGON

By JOSEPH WILCOX, *Oregon Agricultural Experiment Station, Corvallis, Oregon*[1]

ABSTRACT

The Lesser Bulb Fly, *Eumerus strigatus* Fallen, was first reported from Oregon in 1918. This pest is now established in the commercial onion and narcissus producing sections of the state. Brief descriptions of the various stages are given. The larvae have been found in onion, narcissus, and hyacinth bulbs; one grower has reported larvae in tulip bulbs.

The seasonal history records are somewhat incomplete at the present date but may be briefly summarized as follows:—The insect passes the winter as fully grown larvae mostly in the bulbs but in some cases in the soil. During March and April the larvae leave the bulbs and migrate into the upper two inches of soil surface and pupate. The flies emerge and are active during April and May. Mating and egg laying take place at this time. The second generation of flies emerge during June, July, and August. These flies lay the eggs that produce some of the overwintering larvae although some of these larvae may pupate and emerge as flies in September and thus produce a partial third generation.

The larvae are evidently capable of injuring healthy bulbs, but on this question the writer has no conclusive data. The flies, however, show a marked preference for diseased or injured plants for the bulk of their egg deposition. Bulbs infested by this pest are usually entirely destroyed.

This pest can be partially controlled by the hot water treatment as applied for the Stem Nematode, *Tylenchus dipsaci* Kuehn. Sanitation is of value in the control of this pest. Corrosive sublimate and white oil emulsions applied as ovicides in the spring show promise of being practical methods of control for this insect.

INTRODUCTION

The Lesser Bulb Fly, *Eumerus strigatus* Fallen[2], was first reported from Oregon in 1918 and has been reported since on several occasions. Cole (1918)[3] reports *E. strigatus* on onions from Forest Grove; Cole (1920)[4] gives the first published report of *E. strigatus* breeding in onions in the United States at Hood River; Cole and Lovett (1921)[5] in their list of

[1]The writer wishes to acknowledge his appreciation of the many helpful suggestions and criticisms offered by Professor Don C. Mote, Entomologist, Oregon Agricultural Experiment Station, during the course of this work.

[2]Specimens of flies reared from both narcissus and onion bulbs were determined by Mr. C. H. Curran as *Eumerus strigatus* Fallen and *Eumerus tuberculatus* Rondani. However as other Dipterists to whom specimens have been submitted were doubtful as to the validity of the second species, I have only retained the one specific name. No apparent difference could be noted in the life history and habits of the two forms of flies mentioned above.

[3]Cole, F. R.—Emergency Entomological Service, No. 11, May 1, 1918.

[4]Cole, F. R.—Entomological News, Vol. XXXI, No. 2, page 31, 1920.

[5]Cole, F. R. and Lovett, A. L.—Proceedings of the California Academy of Sciences, Fourth Series, Vol. XI, No. 15, Dec. 14, 1921, XV, p. 329.

Oregon Diptera give Corvallis and Hood River as localities where this species has been taken.

The presence of this pest in a region where onions are grown on a commercial scale was first noted in 1924. Onions collected at Lake Labish (Marion County) by Professor Don C. Mote in May, 1924, were turned over to the writer to examine for the larvae of the Imported Onion Maggot, *Hylemyia antiqua* Meigen. In addition to the maggots of *H. antiqua* the maggots of *E. strigatus* were found. The identity of these maggots was not determined until July of the same year when numerous adults emerged. In September 1925, we also received onions infested with the larvae of *E. strigatus* from Washington county, the other county in Oregon producing onions on a commercial scale.

During 1925 we received a number of narcissus bulbs infested with the larvae of *E. strigatus* which were recently shipped to this country from Holland. This is evidently how the pest made its way to Oregon.

The Imported Onion Maggot, *H. antiqua*, is well established in the commercial onion plantings at Lake Labish and the Experiment Station began its work there on this pest in 1923. With the discovery and identification of *E. strigatus* at Lake Labish in 1924, observations were made on this pest during the remainder of the 1924 season and up to the present date. The years 1925 and 1926 afforded an opportunity to study this insect in several commercial plantings of narcissus heavily infested by the Lesser Bulb Fly.

Descriptions of the Various Stages

The Eggs. The eggs are chalk white in color; average length .72 mm. and maximum diameter .24 mm. They are sub-cylindrical in shape, one end tapers to a point and the other is rounded. The sculpturing of the chorion under high power is shown as short, irregular, longitudinally running grayish patches, surrounded by white. The chorion seems to be quite delicate and is easily ruptured, showing the shell underneath to be a pearly white. The eggs are easily distinguished from the eggs of *H. antiqua* and of the Greater Bulb Fly, *Merodon equestris* Fab. by their shape and their much smaller size.

The Larvae. The full grown larvae average from 7 to 10 mm. long (including posterior respiratory process), 2.5 mm. wide and 1.8 mm. high. The larvae are usually a dirty greenish gray color but they have been found to vary from a white to a light red color depending on the medium in which they are working. They are extremely wrinkled, spinulose, and are somewhat flattened ventrally. The anterior spiracles are rather indistinct but the posterior respiratory process projects prominently from the posterior end and is usually brick red in color. The tubercles that are lateral to the posterior respiratory process are characteristic and prominent. The extremely wrinkled appearance of the full grown larvae and the presence of the brick red posterior respiratory process and lateral posterior tubercles will serve to distinguish the larvae of *E. strigatus* from any other to be found in bulbs.

THE PUPARIA. The puparia average in length from 6 to 8 mm. long (including the posterior respiratory process), 3 mm. wide and 2.8 mm. high. The color is usually a light, dirty gray but some may be a brown color while others are red. The exterior of the puparium is very rough especially where the larvae pupate in the soil as the puparium is covered almost entirely with fine particles of dirt. The color of the puparia is the same then as the color of the soil in which they are found or in some cases the same color as the bulb. The anterior pupal respiratory cornua are very prominent and the posterior respiratory process and tubercles are prominent as in the larvae.

Fig. 44.—Puparium of Lesser Bulb Fly, lateral view.

THE ADULT FLIES. For a complete description of the adult flies see Cole (1921)[4]. The adult flies vary greatly in size and are from 5 to 9 mm. long. The body and legs are more or less robust. The body is a metallic bronze color which flashes in

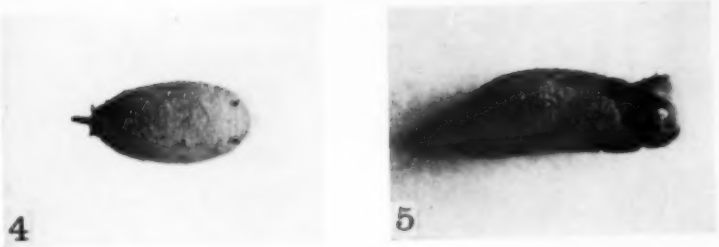
Fig. 45.—Female, Lesser Bulb Fly with wings folded as normally held at rest.

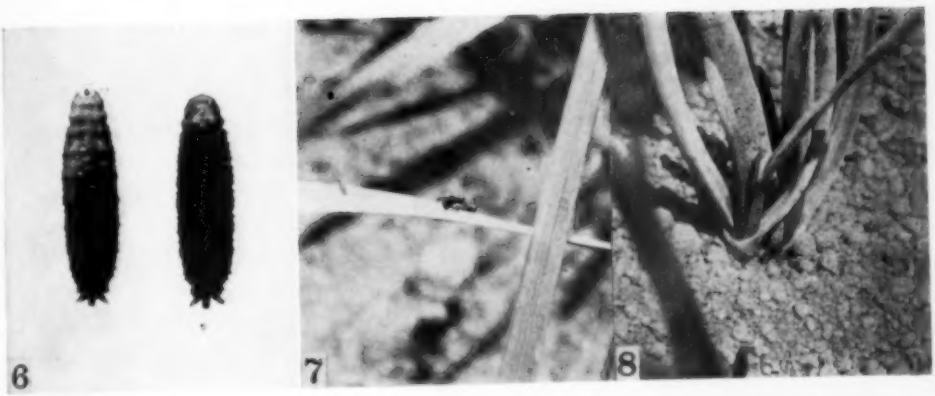
Fig. 46.—Male, Lesser Bulb Fly.

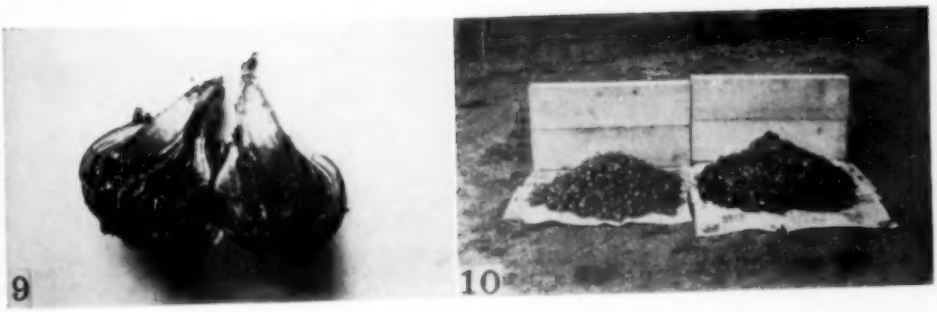
the sunlight. The abdomen is marked with three pairs of crecentric shaped white pruinose bands. The males are usually smaller than the females and can be distinguished from the females by their eyes; the eyes of the females being widely separated while those of the male touch for a short distance just above the antennae.

PLATE 10.—1. Eggs of Lesser Bulb Fly as deposited on the base of a narcissus leaf; 2. Eggs of the Lesser Bulb Fly (above) and eggs of the onion maggot (below); 3. Egg of the Greater Bulb Fly (above) and eggs of lesser Fly (below) as deposited on a clod of dirt; 4. Puparium of Lesser Fly, dorsal view; 5. Fly emerging from puparium, lateral view; 6. Full grown larvae, ventral view on left, dorsal view on right; 7. Flies copulating on a narcissus leaf; 8. Fly ovipositing in the ground at the base of an onion plant; 9. Narcissus bulb injured by Lesser Fly; 10. Total bulbs from four untreated beds of narcissus, those infested by Lesser Fly on right, healthy bulbs on left.

1
2
3


4
5


6
7
8


9
10

Seasonal History

The seasonal history records are somewhat incomplete at the present date but may be briefly summarized as follows:—The winter is passed as fully grown larvae mostly in the bulbs, but in some cases in the soil. During March and April the larvae leave these bulbs and migrate into the upper two inches of soil surface and pupate. The first generation of flies emerge and are active during April and May. Mating and egg laying take place at this time but mainly in the latter part of April and the early part of May. The second generation of flies emerge during June, July, and August. A partial third generation of flies emerge in the latter part of August and in September. The flies are therefore present in some numbers from the first of April until the latter part of September. The eggs that are laid in August and September produce most of the larvae that pass the winter.

Life History and Habits

The Eggs. The eggs are laid principally in the soil adjacent to the plant, the majority being about ¼ inch deep. Some eggs are deposited directly on the surface of the soil while others have been found three inches deep in the ground, the ground here being cracked, making it possible for the fly to crawl down there to lay the eggs. A number of eggs are found deposited on and under the dead skin covering the bulbs and on the base of the leaves. After the leaves have died down in the early summer and the ground cracks, a number of eggs are found deposited on the nose of the bulb but the soil is still the preferred place. After the bulbs have been dug the eggs may be laid on the bulbs in storage. The eggs are laid singly or in groups of from 2 to 20. More than 100 eggs have been found deposited around a single plant. Hatching takes place in from 5 to 10 days. The earliest record of eggs being deposited in the field is April 12.

The Larvae. The newly hatched larvae emerge from the egg by cutting a short longitudinal slit at the pointed end of the egg. These larvae are a trifle longer than the egg and are narrower and entirely white in color. The posterior respiratory process does not take on its brick red color until the larvae are about 4 mm. in length.

The length of the larval stage seems to depend entirely on temperature. By bringing larvae into the warm laboratory any month of the year they could be induced to pupate and emerge as flies. This was especially noticeable during the winter months although some of the flies could not be so forced at this time. The larvae outdoors were inactive all winter and had their mouth parts retracted. The length of

the overwintering generation of larvae is quite long, extending from August to March or a period of seven months. The length of the spring generation of larvae is on the average about 30 days.

THE PUPAL STAGE. The larvae usually migrate into the upper two inches of soil surface to pupate. Some puparia may be found on the surface of the soil while others are four inches deep. A number of larvae also pupate in or on the bulbs or in the boxes or trays in which the bulbs might be stored. The average length of the pupal stage for the overwintering generation is about 30 days, the minimum being 18 days and the maximum 40 days. The pupal stage of the summer generations is shorter, being from 7 to 14 days.

The overwintering larvae pupate in March and continue to pupate into April. The puparia of the summer generations of flies may be found from June to September.

THE ADULT FLIES. They release themselves from the puparia by bursting off the two small pieces of the puparium at the anterior end, the upper piece carrying with it the anterior pupal respiratory cornua. After emerging from the puparium the flies take about a half hour to unfold their wings and for the pigments to form in the chitin before they are active.

The flies are present in the field from April 1 to September. They are most numerous during April and May and are least numerous during June. They then occur in more or less scattered numbers until fall.

The flies are only active in the sunlight, at which time they are restless, flying very close to the ground, hovering over and resting on the soil and leaves of the plants. On cool and cloudy days the flies are inactive and are hard to find. On such days it is quite possible to approach and pick up a fly in your fingers while on sunshiny days it is difficult to catch and retain the flies in a net. The flies when at rest always fold their wings together over the abdomen. The average length of life of the flies is about 20 days. Flies have been kept alive as long as 36 days in our cages. The main requirements for keeping the flies alive a maximum length of time are cool and humid conditions.

COPULATION. Copulation takes place in the bright sunlight usually in the heat of the day. The male follows the female in flight and pounces on her back when she alights. The male acts as a passenger on the back of the female until the copulation process begins. He rests there with his wings folded and clasping the female around her abdomen with his legs while she flies to a suitable resting place which is usually on a leaf but sometimes on the ground. When the male is astride the female she keeps her wings at an angle of 45° with her body and as soon as the

copulatory appendages are engaged the male begins to vibrate his wings rapidly, this wing vibration lasts from 1 to 3 minutes. During the time that the male is vibrating his wings, although the female is disturbed and flies to another place, the wing vibration continues in flight as well as at rest.

OVIPOSITION. Oviposition takes place only on sunny days but usually in the cooler part of the day. The female moves about the base of the plant with her ovipositer extended and with her wings folded over her abdomen. At frequent intervals she stops and the eggs pass out without any apparent movement or excitement on her part.

DISTRIBUTION AND HOST PLANTS

Our records now show this pest to be established in Multnomah, Marion, Clackamas, Washington, Hood River, Tillamook, Clatsop, Polk, and Benton counties. It therefore occurs in limited numbers all through the northwest portion of the state which includes practically all of the commercial onion and narcissus plantings. Although the food plant list of *E. strigatus* is quite large the larvae have been found only infesting onion, narcissus and hyacinth bulbs. One grower has reported the larvae in tulip bulbs but this report has not been confirmed to date.

INJURY

There is considerable discussion in the literature as to whether or not this insect attacks healthy bulbs. As a rule bulbs infested with larvae are in a partial or complete state of decay and putrefaction, especially in onions. A number of onion and narcissus bulbs have been found which from all indications were healthy before being attacked by the larvae. There is little doubt but what the larvae are capable of injuring healthy bulbs, however, it is also evident that the flies select injured or partly decayed bulbs for a large part of their egg deposition. Onions injured by the onion maggot and narcissus bulbs injured by various agencies afford ideal entrance places for the larvae of *E. strigatus*.

The larvae usually begin to attack the bulb at the base but some bulbs can be found with larvae in the neck of the bulb while the base is solid. The point of entrance of the larvae in the bulb is usually at the depression between the basal plate and the bulb proper. Bulbs that are heavily infested with larvae usually have the roots or basal plate entirely eaten off. In most cases bulbs infested by the lesser fly are entirely destroyed.

Infested narcissus plants in the field are detected early in the spring by the stunted and yellowed leaf growth. Later these bulbs are the

first to cure down. Large onions infested with lesser fly can usually be detected by the entirely dead top. This injury is more severe than that caused by the onion maggot in a large bulb. Large onions infested with the onion maggot will usually keep on growing but those attacked by the lesser fly are entirely killed. In many cases the bulbs are so destroyed that only the two hard outside layers of skin of the bulb remain.

Seventy-six larvae of the lesser fly, most of which were full grown, have been counted in one onion bulb. More than 100 larvae have been counted in narcissus bulbs on several occasions. The record number of larvae counted from one narcissus bulb is 267 and was made by Mr. Sidney C. Jones of this department. Larvae numbering from 50 to 100 to a bulb are not uncommon in the three kinds of bulbs in which this pest has been found.

Relation to Disease

Hyacinth bulbs attacked by "Yellows" a bacterial disease caused by *Bacterium hyacinthi* Wakker do not seem to be especially attractive to the lesser fly. This disease causes the heart of the bulb to rot rapidly, turning it into a thick creamy fluid. Only one bulb out of seventeen infested with this disease that were examined contained larvae of the lesser fly, while a number of other bulbs that were not so diseased contained lesser fly larvae.

The flies apparently show a preference for narcissus bulbs infested with the Stem Nematode, *Tylenchus dipsaci* Kuehn. Professor M. B. McKay, Pathologist, Oregon Experiment Station, called the writer's attention to this fact and placed a number of bulbs at our disposal to examine for the lesser fly. The beds of narcissus from which the following records were taken were examined by Professor McKay in April 1926 and the per cent of nematode infestation recorded.

Table 1. Per Cent of Stem Nematode Infestation as Compared with the Per Cent of Infestation by the Lesser Bulb Fly

% of bulbs infested with nematode	Total No. of bulbs examined for lesser fly	No. of bulbs infested by lesser fly	% of bulbs infested by lesser fly
4	65	4	5.79
65	276	113	41.02

Professor McKay also placed at our disposal a number of Golden Spur bulbs heavily infested with nematode that were given the Hot Water and Semesan treatments in September 1925. These bulbs were all from the same lot and were grown at Corvallis after treatment. The per cent of nematode infestation on the plants was recorded in April 1926.

TABLE 2. PER CENT OF STEM NEMATODE INFESTATION AS COMPARED WITH THE PER CENT OF INFESTATION BY THE LESSER BULB FLY IN BULBS GIVEN THE HOT WATER AND SEMESAN TREATMENTS[1]

Treatment	% Nematode infestation	Total number of bulbs examined	No. of bulbs infested by lesser fly	% of bulbs infested by lesser fly
Hot Water 110–111°F. 3 hours	0	116	4	3.44
Semesan 1–400 @ 100°F. 3 hours	43	51	24	47.05
Untreated	86	42	27	64.28

[1]Bulbs dug and examined first week in August 1926.

From the above data it is apparent that bulbs attacked by the stem nematode offer nearly ideal conditions for the attacks of the lesser fly. Whether it is the type of injury that the nematode causes or the organism itself that attracts the fly, is difficult to say. It is probably the former, however, as it has been noticed that although the flies are attracted to most injured bulbs; onion, narcissus, and hyacinth bulbs that are injured and have fermented to a point where a distinct acid odor is given off are not found attacked by the fly. This apparent discrimination on the part of the flies may be partly explained by the fact that a few flies have been taken from traps placed in the onion fields that were baited with alcoholic fermentations of honey and molasses.

It is also apparent from the above data that the hot water treatment aids materially in the control of the lesser fly. Whether the per cent of injury would be cut down this low or not in plantings that are entirely given the hot water treatment, will have to be determined by further observations and experiments. Due to the uncertainty and unfamiliarty of the growers with the hot water treatment in 1925, all the stock was not treated. During the 1926 season practically 100% of the narcissus bulbs will be given the hot water treatment.

CONTROL

The Hot Water Treatment,[6] that is, immersing the bulbs in water at a temperature of 110.5°F. for three hours as applied for the stem Nematode, *Tylenchus dipsaci* Kuehn, in narcissus bulbs will kill all the larvae present in the bulb. This treatment is not a cure-all, however, as it is impossible to get all the bulbs from the ground when digging and especially the ones infested with the lesser fly. This is not possible for

[6]Doucette, C. F.—Jr. Ec. Ent. Vol. 19, p. 248, 1926.

several reasons, in the first place there is nothing left of some of the bulbs but the skin and a small amount of rotted tissue and this bulb is easily overlooked in digging but may contain upwards to 100 larvae and secondly when handled the larvae drop from the bulbs into the soil where it is impossible to recover them.

Sanitation

Bulb growers can rid themselves of a great number of larvae by destroying all soft and decaying bulbs at the time of digging. Care should be taken to keep the flies from the bulbs between the time of digging, treating, and planting and if possible the planting should be removed from one locality to another each year so as to minimize the attacks of the bulb flies. Especial care should be taken to remove all the bulbs possible from the ground at the time of digging. Onion growers can get rid of infested onions when they are sorting over the onions for market. An abandoned field of seed onions and a plowed under field of set onions served as an ideal place for the writer to make observations on this pest during the winter.

Experiments for 1926

The hot water treatment and culling are at best but poor methods of control for the lesser fly. The maggots are killed after the damage is done and then the grower leaves enough maggots in the ground to be assured of a maggoty crop the next season. Therefore, the following outlined experiment was arranged and conducted on a commercial planting of narcissus the past spring.

Table 3. Field Treatment for the Control of *Eumerus strigatus* Fallen on Narcissus—1926[1]

Treatment	Total No. bulbs in plot	No. infested by lesser fly	Per cent of bulbs infested
Dormoil 2%	741	152	20.51
Corrosive sublimate 1 oz.–10 gal. water	816	31	3.79
White oil emulsion 4%	681	27	3.95
Check—no treatment	736	258	35.05

[1]Bulbs dug and examined June 22, 1926.

The bulbs treated in the above experiment were of the Mrs. Langtry variety and were planted in rows approximately 100 feet long. Fifteen gallons of solution were used to each row per application. The solution was poured around the base of the plants and was applied with a watering can from which the sprinkler had been removed.

It was planned to make the applications at weekly intervals so as to kill all the eggs laid within a weeks time. Rain interfered twice, preventing the application of the solution at the appointed time. The applications were made on the following dates: 1st—April 23; 2d—April 30; 3d—May 10; 4th—May 17; 5th—May 27. The average interval between the applications was 8.5 days.

The corrosive sublimate[7] used was dissolved in concentrated hydrochloric acid at the rate of 1 ounce of $HgCl_2$ to 1 ounce of HCl as used by Glasgow (1925)[8] for the control of the cabbage maggot, *Hylemyia brassicae* Bouche. This method makes the handling of corrosive sublimate quite simple.

Considerable leaf burning was noted in the Dormoil and corrosive sublimate plots which caused the plants to cure down several weeks earlier than the untreated plants. No detrimental results from the burning could be noted on the bulbs however. It is planned to continue these experiments next season and to grow some of the bulbs treated last season so as to further determine the effect of these treatments on the eggs of the fly and the growth of the bulbs.

Conclusions

The Lesser Bulb Fly is well established in the commercial onion and narcissus plantings in Oregon. Onions, narcissus, and hyacinth bulbs have been found attacked.

The question as to whether this pest attacks healthy bulbs or not is still left unsettled, however, it is believed that the larvae are capable and do injure healthy bulbs but that they prefer to attack unhealthy bulbs.

Nevertheless this insect must be taken into consideration in bulb production as it does attack bruised, diseased, and otherwise injured bulbs and destroys them. Without the agency of the lesser fly these bulbs would either recover from the injury or the primary cause of the injury could be controlled.

Treatments of corrosive sublimate and white oil emulsions applied as ovicides to the plants in the spring show promise of being practical

---

[7]The corrosive sublimate treatment also gave 100% control of the Greater Bulb Fly, *Merodon equestris* Fab. The other treatments did not give as good results in the control of this pest. The per cent of injury by the Greater Fly in the various plots was as follows: White Oil Emulsion 4%, 6.75% injury; Dormoil 2%, 2.02% injury; Corrosive Sublimate 1 oz.–10 gal. water, 0.00% injury; Check—No Treatment, 7.06% injury.

[8]Glasgow, Hugh—N. Y. Agr. Exp. Sta. Bull. 512, Feb. 1925, p. 73.

methods of control for this pest. This treatment combined with the Hot Water Treatment and sanitary measures of control will give the best results in controlling all of the narcissus bulb pests.

The extent of the injury that this pest causes to onions has not been determined but the percentage of injury caused by the Lesser Fly to date has been small as compared with the injury caused by the Imported Onion Maggot.

Mr. C. A. Weigel spoke of the recent quarantine against this insect, and the unsuccessful attempt of importers not only to defeat this quarantine but make its defeat an entering wedge to ultimately destroy all such quarantines.

H. J. QUAYLE spoke of the danger of importing any phytophagus insect, even though it feeds on an injurious plant in its native home, because of the possibility of the insect changing its food habits, citing the codling moth as an example. This insect formerly fed only on apples and pears, but in recent years has become a serious pest of walnuts

Mr. F. B. HERBERT: We have taken codling moth larvae in Marobalan plums.

MR. T. D. URBAHNS: In the Sacramento valley Kelsey plums near apple trees have become infested with the codling moth.

MR. E. J. NEWCOMER: In the Yakima valley, infested Italian prunes and cherries have been taken. The prune tree was growing so close to an apple tree that the branches mixed.

MR. H. J. QUAYLE: Three years ago, in an orange orchard, in the center of which was a walnut drying house, a number of oranges infested with codling moth larvae were taken; infested apricots are now common in southern California.

CHAIRMAN HERMS: The next paper is by T. P. Cassidy.

THE ARIZONA COTTON BOLL WEEVIL PROBLEM

By T. P. CASSIDY, *Associate Entomologist Southern Field Crop Insect Investigations, U. S. Bureau of Entomology*

ABSTRACT

The Arizona boll weevil is a variety of the well known boll weevil of the South. It is, however, specially adapted physiologically to thrive in arid regions. The natural host plant of the Arizona boll weevil is Thurberia or wild cotton. It has invaded cultivated cotton, however, and is now a serious menace. The injury at present is confined to Pima and Santa Cruz Counties but is likely to spread. It has been demonstrated that the Arizona weevil accepts cultivated cotton readily. This

invasion is of the utmost importance. Research work on this pressing problem is now under way.

The Thurberia plant which is the natural host plant of the Arizona cotton boll weevil is found throughout the southwestern quarter of the state of Arizona. It is also known to occur along the western slope of the Continental Divide down through Mexico, as far as Guadalajara. There is also possibility of its occurrence in the extreme southwestern portion of New Mexico, though no investigations have been made in that section. The plant occurs only in the mountain ranges or along the dry washes extending down from the canyons of the ranges through the foothills and across the mesa. The Thurberia weevil is found only through a limited portion of the range of the plant and by far the greatest concentration of individual infestation has been found in what is called the Tucson district, primarily in Pima, Santa Cruz, and Cochise Counties, and possibly a small portion of Pinal County.

The district in question produces not more than one-sixth of the cotton produced in the state of Arizona. This is entirely raised under irrigated conditions, the majority of the water being derived from deep wells, and the pumping constitutes a very heavy charge against the crop. During the flood seasons additional irrigation is provided by ditches from the Santa Cruz River, but this source of supply cannot be counted on, and the backbone of the production is the well system. Under such circumstances production costs are naturally high, in at least some portions of the district, and the profit in production is exceedingly doubtful in spite of large crops. This section normally averages approximately a bale to the acre and any appreciable reduction in yield would force the abandonment of cotton growing owing to the high cost. The entire cultivated area in this district is distributed along the Santa Cruz River which rises partly in Arizona and partly in Mexico, in the immediate vicinity of Nogales. It then flows almost due north, approximately seventy miles to Tucson, where it turns to the westward and travels in this direction until it vanishes in the desert about Casa Grande. This river, is, of course, dry almost all of the time but provides an underground source of water for pumping, and during the brief rainy periods, floods rush down the river channel and out through the various flood ditches. Such a flood may be caused at any time by a rain up in the mountains which furnish the watershed for this river. The flood may last several days or only a few hours, but the fall is such that the water rushes with terrific force during its travel.

Cultivated cotton along this river starts with a series of small fields about eighteen miles north of Nogales or in the vicinity of Tubac,

Arizona. The largest single area is at Continental, where the fields are distributed along both sides of the river for several miles, a total of approximately twenty-seven hundred acres of cotton being planted at that point. The next cotton down the river is at Sahuarita, where there is something over a thousand acres. This area is located about fifteen miles south of Tucson. There is no more cotton until about ten or fifteen miles north of Tucson where the principal area of cotton production starts. This area extends more or less continuously until in the neighborhood of Red Rock. In all, the district described from Nogales to Red Rock along the Santa Cruz River had about ten or twelve thousand acres of cotton during the past season. Beyond Red Rock there is a considerable gap, the nearest cotton being about thirty-five miles away at Casa Grande where a small acreage is planted. There is also a considerable tract of cotton around Florence and these two tracts constitute the only stepping stones between the cotton area of the Santa Cruz Valley and the main cotton district of the Salt River Valley which is, of course, centered at Phoenix.

As has been mentioned, practically all of this cotton is planted right along the river, furthermore, this valley is bordered on both sides by mountain ranges, extending north and south. The crest of these ranges is frequently around eight to nine thousand feet, and the base ranges from three to four thousand feet. Then the high mesa slopes rapidly to the valley and the small level areas which are put into cotton vary from about thirty-five hundred to two thousand feet, the higher points, of course, being nearer the source of the river toward Nogales, and the lower levels being in the vicinity of Red Rock. Drainage from the mountains on both sides pour immediately into this river through innumerable arroyas and dry washes and after Tucson is passed, additional stream beds are encountered, draining other valleys and these combine with the Santa Cruz. Weevil infested Thurberia plants are found throughout this entire district. In the upper slopes of the mountains they are found more or less promiscuously, that is on the slopes, ridges or in the canyon beds but in the lower levels they are found only in or immediately adjoining the washes. Examination shows that these plants, particularly in the district south of Tucson, extend continuously from the upper mountain distribution right down in the washes through the cotton fields and in several instances plants have been found growing within a few feet of cultivated cotton. This distribution is due to two factors—one is the necessity for moisture to permit plant growth and the other is the fact that the plant is ideally adapted to be spread by water flow. Both the bolls and the individual seeds can be

washed very readily for great distances, furthermore, the weevil infested boll is especially adapted to water carriage as the weevil hibernates in a cell formed within the boll in such a manner that the boll is held perfectly intact and it will stand a great deal of rough treatment before it can be broken open. It floats readily and undoubtedly is washed for a great many miles in the floods. Recent experiments show that weevils can survive for a period of eighteen days or longer when completely submerged under water in their hibernating cells, and also weevils that have been removed from their cells can be completely submerged under water for a period of fourteen days or longer and still survive. An interesting example of such transportation is shown by the finding of a Thurberia plant in a cotton field about a mile from Postvale. This plant is growing on the side of a small subirrigation ditch and conditions there are such that it was undoubtedly carried by water for a great many miles in reaching this location.

The distribution of Thurberia plants and weevils through this district is extremely erratic. One wash may contain thousands of plants while the next one which looks absolutely identical may not have a single one. Within a single wash weevil infestation may be found extending for several miles and then a district of totally uninfested Thurberia plants will be encountered. On the whole the determination of distribution and infestation in the lower levels is more simple than might be anticipated considering the rugged nature of the country due to the fact that the plants are never found away from the washes, but in the mountain range proper, the finding of plants is very much a matter of luck as there seems to be no particular rule for their occurrence and the country is so rough that thorough examination is almost a physical impossibility.

The work conducted near Tucson in 1914 by Mr. B. R. Coad of the Bureau of Entomology, showed the readiness with which this weevil would transfer to cultivated cotton, but at that time there was comparatively little cotton in the valley and it was so located that it had about the minimum exposure to infestation. The cotton acreage in this district fluctuated back and forth until about 1920, when Thurberia weevils were found active in cultivated cotton fields. The cotton acreage was then small and there was no particular incentive for continuing production so a more or less half-hearted non-cotton zone was imposed. This did not operate one hundred per cent but comparatively little cotton was grown in the valley for the next few years. In 1924 a few weevils were found around Postvale in the crop which had been grown in 1923. The State officials declared a non-cotton zone, taking in

this entire district with the dividing line being drawn between Red Rock and Casa Grande. However, something over seven thousand acres of cotton had actually been planted around Postvale before the proclamation was issued. Naturally, an injunction suit followed. The case finally resulted in the court granting a permanent injunction against the Arizona state authorities, prohibiting them from interfering with the growing, handling or disposing of cotton in the infested district.

Because of the increased importance of the problem the Federal Government reopened its investigations at Tucson in the spring of 1925. One feature of the work consisted of making detailed surveys of the fields in this district. This survey was not made, however, until during the past winter, as it was necessary to utilize men who were assigned to other projects throughout the active growing season. Weevil infestation was found in every one of the tracts mentioned above, all the way from near Nogales to Cortaro. It was much heavier in the areas around Tubac, Continental, and Sahuarita than it was in the Postvale district. However, most of the fields had been picked when these examinations were made and our research work showed that a very large proportion of the weevils are removed during the process of picking. Obviously a heavy infestation of weevils exists throughout much of the Santa Cruz Valley and this infestation may be expected not only to maintain itself but to increase.

Throughout the season a considerable amount of research work was done. For the sake of safety, a one acre tract of cotton was located twenty-six miles southwest of Tucson in the midst of the desert. This cotton was infested with Thurberia weevils and their behavior and biology studied throughout the season. The altitude, temperature, etc., in this tract of cotton was certainly as severe as any in the Santa Cruz Valley. It was found that the weevils took to this cotton very readily and caused considerable damage. This field of cotton was inspected from time to time by various Federal and State Entomologists. Some of these authorities are convinced that this weevil is potentially a more serious menace to cotton in the drier regions than either the pink boll worm or the ordinary weevil is to cotton in the regions most suited to their activities. There are several reasons for this conclusion; in the first place, the Arizona weevil prefers bolls for oviposition, so that hurrying a crop to get it ahead of the weevil, such as is done in the south, will be of no value. Furthermore, the Arizona weevil shows an enormous degree of resistance to extreme conditions. It is able to go into a state of at least partially suspended animation whenever conditions become too hot, too cold, too dry, or unfavorable in any other way and can live in

this condition for a very long period. Hibernation studies conducted the past winter show that approximately seventy per cent of the weevils survived, with temperature conditions about as severe as may ever be expected in this district. This is quite a contrast with the normal survival of only two to five per cent with the ordinary boll weevil. Under the circumstances with the high rate of survival and the preference for bolls for egg deposition, this weevil is certainly a very serious menace. Furthermore, it is ideally adapted for transportation. A high percentage of the individuals of the last generation in the fall form very hard cells in the cotton seeds or lint and most of these will be gathered with the picking. These cells will go through the gin very readily, the majority of them, of course, passing out with the gin waste or with the seed, but undoubtedly many of them will be carried along with the lint and introduced in the bale of cotton. In addition the handling around the gin is bound to disturb many individuals which will be landing on all sorts of objects. Many of these will crawl on cotton bales, into the seed, on wagons, and in fact, any other object with which they can travel. This is going to mean an unusual concentration of individuals around the gins but gives them the best possible opportunity for securing transportation elsewhere.

Due to the above mentioned facts it seems that some definite action should be taken to prevent the Arizona boll weevil from becoming established in cultivated cotton since approximately one-sixth of the normal cotton crop of the United States is produced in the Western area where the ordinary boll weevil cannot thrive sufficiently to cause any damage and it seems possible to double this production within the next few years, provided the territory remains free from insect damage.

CHAIRMAN HERMS: We hear again of the codling moth, this time in cherries.

CODLING MOTH ATTACKS CHERRIES

By DON C. MOTE, *Oregon Agricultural Experiment Station, Corvallis, Oregon*

Last season, 1925, an extensive survey of Oregon's cherry growing sections was undertaken by the Entomology Department of the Oregon Experiment Station for the purpose of determining the limits of cherry fruit fly (*Rhagoletis cingulata*) infestation. As a result of this survey the department received numerous samples of cherries infested with larvae from various sections of the state.

In June a few cherries infested with a codling moth-like larva were

received from County Agent Cate of Medford. These were placed in a rearing cage and in due time two codling moths (*Carpocapsa pomonella* L.) appeared. Our determinations were verified by Mr. Carl Heinrich of the U. S. Bureau of Entomology.

On June 29 we received a small consignment of cherries from Mr. H. A. Scullen, Assistant Entomologist, who was conducting the cherry maggot survey throughout the southern counties. These cherries were picked from a tree at Sutherlin, Oregon, in Douglas County. They were infested with larvae similar to those taken at Medford. Later codling moth were taken from the rearing cages in which these infested cherries had been placed.

About the same time we received a few cherries from Mr. Stewart, Horticultural Inspector of Lane County. These cherries were also infested with codling moth larvae which developed later into codling moths.

The injury caused by the codling moth is due to the entrance tunnel and the feeding of the larva on the pulp near the seed, followed by brown rot and other decay organisms. The tunnelling and external frass so characteristic of the larval work in apple and pear was also evident in the infested cherries.

Several varieties of cherries were found infested. At Cottage Grove, the moth attacked cherries of the Royal Ann type grown on a seedling tree. Bing, Lambert and a variety commonly called Pie cherry were also found infested.

The distribution of the cherry codling-moth-like-larvae during the 1925 season ranged from Lane County south to Jackson County, specimens having been taken from Cottage Grove, Lane County; Yoncalla, Sutherlin, and Roseburg, Douglas County; and Ashland, Jackson County.

Thus far the losses to cherry growers from the codling moth attacks have been negligible. Mr. Scullen reports that he observed from 1 to 4 per cent infestation in the cherries examined, while Mr. Stewart found from 4 to 10 per cent infestation in the seedling Royal Ann tree.

CHAIRMAN HERMS: The final paper on our program is by B. G. Thompson; it will be read by Mr. Don C. Mote.

THE PEACH AND PRUNE ROOT-BORER INJURIOUS TO CHERRIES

By B. G. THOMPSON, *Oregon Agricultural Experiment Station, Corvallis, Oregon*

ABSTRACT

Notes on the injury, life history and parasites. Borers found only in the roots and crown below the union of the bud and root in cherries budded to *Prunus mahalab* root stock. Seedling cherries and cherries budded to seedling root stock were free from attack although planted in immediate vicinity of infested trees.

On September 27, 1925, Mr. Bode in charge of the H. F. Davidson Fruit Company's ranch near Lebanon, Oregon, reported a very heavy infestation of some borers working in the crown and roots of his cherry trees. Upon investigation this was found to be the peach and prune root-borer.[1] Four acres of four year old trees were heavily infested with this borer. As many as 20 larvae were taken from one tree. Every tree examined was found to be infested. Forty trees had already been killed by this insect and many others were in a dying condition. Twenty acres of 12 year old cherry trees in another part of the orchard were also heavily infested with the borer.

An examination of numerous trees throughout the orchard showed no borer present above the union of the bud and root stock. This led to the suggestion that perhaps the root stock was responsible for the attack. Sprouts were obtained from the root stock and determined by Prof. Hartman of the Horticultural Department, Oregon Agricultural College, as *Prunus mahalab*.

Seedling cherries and cherries on seedling cherry root stock were found to be entirely free from borers, although some of these trees were immediately adjacent to the heavily infested orchard.

The life history of this insect on cherry is about the same as on its other hosts. The larvae began to pupate this year (1926) early in May. Adults were on the wing during late May and early June.

CONTROL

On September 28, 1925, a number of the four year old trees were treated with Paradichlorobenzene at the rate of ½ ounce to the tree. The Paradichlorobenzene was placed in a ring around the tree, care being taken to keep the ring at least two inches from the tree. This ring was then covered to a depth of two to four inches. On October 12, 1925, the trees were examined. All the larvae found were dead. Four

[1]Adults were obtained May 25, 1925, and determined as *Synanthedon opalescens* (H. Edw.) by the author.

dead larvae were taken from one tree. To date, June 10, 1926, no injury has resulted to the trees from the use of this insecticide.

A considerable number of larvae were found to be infested with Hymenopterous parasites, but the adults of this parasite have not yet emerged.

NAPHTHALENE FUMIGATION OF GREENHOUSES

By ALBERT HARTZELL, *Boyce Thompson Institute for Plant Research, Inc., Yonkers, N. Y.*

ABSTRACT

Fumigation with commercial flake or ground naphthalene at a concentration of 1.5 oz. per 1000 cubic feet of air space with exposures lasting over night has proved to be an effective and practical method for controlling red spider (*Tetranychus telarius*) and two species of thrips, namely, *Heliothrips femoralis* and *Thrips tabaci* in greenhouses. Observations covering a period of two years in which the tolerance of 40 species of plants was repeatedly tested indicate that this fumigant is adaptable to general greenhouse use. By observing the following precautions injury to the foliage may be avoided. The temperature during fumigation should be approximately 70° F. and a relatively high humidity of about 80% must be maintained throughout the entire period. A slow, even volatilization of the material over a period of at least 6 hours is essential in avoiding foliar injury and obtaining the maximum kill of the pests. This can be brought about by means of a simple device described and illustrated in the text of this article. Fumigation should be done at night and repeated at intervals of about a week. Frequent applications at relatively low concentrations rather than a single application at a high concentration are preferable.

INTRODUCTION

There is an urgent demand for an efficient means of control of red spider and thrips in greenhouses. The commercial growers for years have used various remedies against these two pests, in some instances with considerable degree of success. The following are among the common practices employed for keeping the houses free from infestation: (1) steam sterilization of the soil; (2) discarding infested plants; (3) spraying with water or nicotine preparations; (4) fumigation with hydrocyanic acid gas. While these methods in many cases when persistently applied have proved successful, hitherto no single effective remedy could be recommended by entomologists that would assure immunity. Furthermore the research worker who is growing plants for experimental purposes can not always resort to commercial practices in ridding his plants of these pests, for in many instances that would defeat the purpose of the experiments. Since the development of an efficient fumigant would both aid the commercial grower and those en-

gaged in research, the writer undertook to test out the possibilities of naphthalene. For the past two years naphthalene fumigation has been a regular greenhouse practice at this institution and as the results have been very promising it was considered advisable to publish our observations in the hope that they may be of interest to other investigators and lead to further developments in the control of red spider and thrips.

In a previous paper[1] it has been shown that it is possible to kill red spider by exposing them in a confined space to the fumes of naphthalene. About the time this observation was made, Dr. Ward B. Davis was investigating the effects of gases on plants for the Institute. He performed a number of tests with naphthalene, studying the tolerance of plants to various concentrations of the vapor, and incidentally noted its effect on insects. Pressure of other work caused him to discontinue the naphthalene experiments so the writer undertook to follow up this lead, devoting special attention to the development of methods for greenhouse fumigation for the control of red spider and thrips.

A careful search of the literature disclosed the fact that while little or no work had been done with naphthalene as a fumigant in the United States considerable progress had already been made in England. As this literature is not readily available to American entomologists, a brief account of what the English investigators have accomplished, will be in place here. Speyer[2] found that naphthalene, when heated, is the most effective remedy against red spider (*Tetranychus telarius*) in cucumber houses, provided that within broad limits the amount of vapor in the atmosphere can be controlled so that no burning is caused to the plants. He found that naphthalene in solution volatilized too rapidly, causing injury to foliage. Better results were obtained by distributing the solid material on the heat pipes at the rate of approximately 2 lbs. to each 1000 cubic feet of space. The pipe temperatures ranged from 68° F. to 98° F., while the atmospheric temperatures of the greenhouse varied from 55° F. to 78° F. The fumigation was continued over a period of four days, at the end of which time he states that there was little injury to the foliage and the mites appeared to be dead.

In a subsequent paper he[3] discusses at considerable length the results obtained by broadcasting naphthalene in cucumber and tomato

---

[1]Hartzell, A. and Lathrop, F. H., An investigation of sulfur as an insecticide. Jour. Econ. Ent. 18: 275–276. 1925.

[2]Speyer, E. R., Entomological investigations. Nursery and Market Garden Indus. Develop. Soc. Ltd. Exp't'l. and Res. Sta. 9th Ann. Rept. 1923: 69–81. 1924.

[3]————Entomological investigations. Nursery and Market Garden Indus. Develop. Soc. Ltd. Exp't'l. and Res. Sta. 10th Ann. Rept. 1924: 82–104. 1925.

houses. Pure white commercial naphthalene, in a dry state, which had passed a sieve of 16 meshes to the inch, was broadcasted by hand along the borders, using 3 lbs. to each 100 feet of border. He states that the temperature of the house should not fall below 74° F. nor rise above 104° F. and a relatively high humidity must be maintained during the period of fumigation. Broadcasting was begun about 4 P. M. and the ventilators were closed for the night. The next morning these were opened for a few minutes, after which the plants were watered and the ventilators closed. By the following morning the naphthalene had evaporated. Attempts were made to adapt this method to tomato and carnation houses by using ½ to 1 oz. of naphthalene (16 grade) per square yard for a night and day with the ventilators closed and at temperatures above 70° F.

Parker,[4] in reporting on more recent developments in naphthalene fumigation of greenhouses states that broadcasting has not proved satisfactory with plants other than cucumber, and describes a method of volatilizing naphthalene by means of lamps. The great advantage of this device, he claims, is that it obviates the possibility of injury to exposed roots by contact with naphthalene. Oil lamps holding 3 pints of paraffin were used, sufficient to burn continuously for 36 hours. Over the lamp was fixed a funnel in the shape of an inverted cone on the top of which was placed an aluminum pan containing the naphthalene. One lamp was sufficient to fumigate 6000 cubic feet with 5 to 5–½ lbs. of naphthalene (16 grade). This was at the rate of approximately 13 oz. per 1000 cubic feet.

Fumigation was begun at 4 P. M. and continued for at least 12 hours. He states that at this concentration 90–95% of the mites were killed. The house temperature must be within 70°–105° F. during fumigation. Thorough ventilation after fumigation is advised. He recommends three applications at relatively low concentrations at intervals of a week rather than a single fumigation at high concentration in order to avoid injury to the plants.

Materials and Methods

Both commercial flake and ground naphthalene (melting point 174.2° F.) in a solid state were used in our experiments with equal degrees of success. Box fumigations were employed in making the preliminary tests on the toxicity of this fumigant to red spider (*Tetranychus telarius*)

[4]Parker, T., The control of red spider. Hort. Trade Jour. 29 No. 39: 27–28; No. 40: 27–28. 1925.

and in determining the tolerance of plants to various concentrations of the vapor. When the experiments had progressed to the point of reasonable safety, greenhouse fumigations were undertaken.

A large galvanized iron box, with a door capable of being securely clamped in place, was used in making the initial trials. A motor driven fan, which insured uniform distribution of the vapor, electrical connections for a hot plate and a bi-metal control for keeping the temperature of the box uniform were installed. Later the use of the fan and hot plate was discontinued and volatilization was accomplished by spreading ground naphthalene on large sheets of paper and keeping the box at a constant temperature of 68° F.

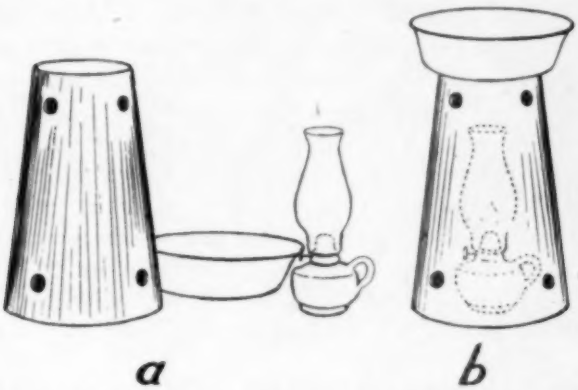


Fig. 47.—A simple apparatus for fumigating with naphthalene; *a*, parts unassembled; *b*, parts assembled.

The earlier greenhouse fumigations were made by placing the naphthalene in a porcelain dish on an electric hot plate and distributing the vapor throughout the house by means of a motor driven fan. As the investigation progressed this method was abandoned for an oil lamp covered with a truncated sheet iron cone on top of which the naphthalene was placed in a flat bottomed pan. By regulating the height of the flame it was possible to adjust the rate of volatilization so that the material would be given off in 6 hours. This device which is very simple and inexpensive is illustrated in figure 47. The following are the dimensions of the sheet iron cone: height, 15 inches; diameter at top, 6 inches; at base, 8 inches. Four openings, above and below, about 1 inch in diameter are provided for a draft. The lamp is of the ordinary kerosene type, having a reservoir with a capacity of one-half pint and a burner with a 5/8 inch wick. The top of the chimney should come

within 2 or 3 inches of the bottom of the pan and the diameter of the latter should be approximately 8 inches. Our experiments have shown that a lamp of this kind will burn for a period of about 6 hours and generate enough heat to volatilize 9 oz. of naphthalene which is sufficient to fumigate 6000 cubic feet of greenhouse space. By means of this method a slow, even distribution of the vapor throughout the house is accomplished and injury to the plants avoided and the maximum toxicity to insects and mites assured. Fumigations were begun at 5 P. M. and continued until 7 A. M. when the ventilators were opened and the house thoroughly aired.

Experimental Results

A series of box fumigations were conducted to determine the minimum dose necessary to kill mites for different lengths of exposure. Infested potted plants were used in these tests. It required relatively high concentrations of the vapor, involving considerable risk of injury to the foliage, to secure a fatal dose when the period of exposure was 8 hours or less. Better results were obtained by reducing the dose and lengthening the period of treatment. We found that with our apparatus 1.5 oz. of ground naphthalene at a uniform temperature of 68° F. volatilized approximately .4 oz. which was sufficient to kill the mites when exposed for a period of 42 hours. Slow fumigation is preferable because there is less danger of injury to the plants and of the mites recovering.

These trials were followed by greenhouse experiments of which table I represents a typical example.

Table I. Showing the Effects of Repeated Naphthalene Greenhouse Fumigations on Red Spider and Thrips.

Application number	Interval in days	Dosage ounces per 1000 cu. ft.	Temp. °F.	Humid. per cent	Length of fumigation hours	Per cent dead Red Spider	Per cent dead Thrips
First.....	—	1.5	74	80	14	80	70
Second.....	1	1.5	78	80	14	98	97
Third.....	7	1.5	76	76	15	100	100
Fourth.....	1	1.0	78	80	15	100	100

Our experience based on many observations indicates that naphthalene fumigation at the rate of 1.5 ounces per 1000 cubic feet of greenhouse space will keep red spider and thrips[5] under control.

At the same time experiments on the toxicity of naphthalene were

[5]The plants were infested with two species of thrips, namely, *Thrips tabaci* and *Heliothrips femoralis*. I am indebted to Prof. G. W. Herrick for the identification of the last named species.

conducted, opportunity was afforded to note the effects of exposures of various species of plants to this fumigant. The tolerance of the following species was noted:

Asclepias nivea	Corn	Mustard
Aster, China	Cosmos bipinnatus	Nasturtium
Barley	Cotton	Oats
Beets	Cucumber	Peach
Buckwheat	Eggplant	Pepper
Cabbage	Four o'clock	Potato
Calendula officinalis	Gallardia grandiflora	Radish
Tagetes erecta	Geranium	Rye
Carrot	Helianthus	Scabiosa
Centaurea imperialis	Hyacinth orientalis	Sonchus
Clover, alsike	Hippeastrum equestre	Sorghum
Clover, red	Hollyhock	Soy bean
Coleus blumei	Lettuce	Spinach
		Tomato

Of the 40 species listed above which were given repeated fumigation in the greenhouses, soy bean was the most susceptible to injury, while buckwheat, pepper, radish, red clover and tomato on different occasions showed slight injury to foliage but recovered fully within a week or ten days.

Cost of Treatments

Commercial naphthalene of the grade used in these experiments when purchased in small lots costs 20 cents per pound. If used at the concentration recommended in this paper the cost of fumigation per 1000 cubic feet of greenhouse space would be approximately 2 cents. If the naphthalene, however, is purchased in lots of 100 lbs. or more, the cost of material for a single treatment may be reduced to less than 1 cent per 1000 cubic feet.

Discussion

While not all the factors involved in naphthalene fumigation have been worked out with finality, the writer feels that sufficient progress has been made to indicate in a general way, the limits of safety so far as humidity, temperature and dosage are concerned. Our preliminary results corroborate those of Speyer and Parker that a relatively high humidity is essential and that the temperature during the period of fumigation should not fall below 70° F. if injury to the foliage is to be avoided. In addition to temperature and humidity, light is an important factor. When plants which had been fumigated were subsequently exposed to artificial illumination of an intensity of approximately 300 foot candles severe foliage injury was noted in certain cases, while the

check plants, which received the same dose and were identical in other respects were uninjured. These and other observations lead us to conclude that plants fumigated in darkness are not so liable to injury as those fumigated in light and that fumigation at night is desirable. From the evidence on plant tolerance it is likely that this fumigant will have a wide range of usefulness for general greenhouse work. There remains considerable investigation to be done along the line of defining more accurately the factors affecting fumigation. The main attention of this study was centered on the destruction of thrips and red spider and as the latter form undergoes several periods of quiescence during its life cycle, observations were made over a period of forty-eight hours following fumigation to insure that there was no recovery. During the course of this work opportunity was afforded from time to time to note the effects on other greenhouse pests. While it is possible to kill both white fly and aphids by repeated fumigations, it appears that naphthalene has selective toxicity to red spider and thrips not shown for other species. Furthermore, from our present state of knowledge, naphthalene seems to be the only fumigant that offers relief from these two pests.

A CONTACT SPRAY FOR THE CONTROL OF THE JAPANESE BEETLE (*POPILLIA JAPONICA* NEWM.)[1]

By E. R. VAN LEEUWEN, *Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

This paper deals with an emulsion of oleoresin of pyrethrum flowers and sodium oleate as a contact spray for the control of the Japanese beetle, *Popillia japonica*. The experiments include laboratory and field tests on various types of plants for injury and toxicity tests on the beetle.

INTRODUCTION

There is a distinct demand for a contact insecticide for use against the Japanese beetle which can be depended upon to give a satisfactory kill. That an efficient contact spray will have considerable application, under certain conditions, is especially true at this time in view of the fact that a suitable attrahent for the beetle has recently been developed (1).

DISCUSSION OF THE PROBLEM

It is apparent from the records on file in the Japanese Beetle Laboratory at Riverton, New Jersey, that nearly every known contact spray

[1]Contribution No. 14 of the Japanese Beetle Laboratory, Riverton, N. J.

has at one time or another been used on the beetle. Hundreds of mixtures received from the public, which proved to have no insecticidal value whatever, have been tested. On the other hand, many materials have been received which showed high toxicity when used on the beetle. Especially is this true of the oil sprays. The great difficulty encountered with sprays of this class, as well as with the various other materials used, is that there is no margin of safety between the dose that the foliage can stand and that required to destroy the beetle. However, the value of certain soap solutions for destroying the beetle has been known for some time (2). On account of their toxic action on the foliage, their usefulness when employed in quantities large enough to produce a satisfactory kill as contact sprays is limited (3).

Experimental Procedure

Having in mind the insecticidal value of a soap and the many qualities in its favor, a considerable number of experiments were made during the season of 1924 with different commercial varieties. These soaps, used under comparative conditions, gave varying results as to kill of beetles and injury to foliage, owing, no doubt, to the fact that they were not alike in composition. To correct this condition, a twenty per cent soap was made at the laboratory from oleic acid, U. S. P., and sodium hydroxide, C. P. The results obtained in a series of tests with this soap were more uniform than the results obtained from the use of the commercial soaps. No injury to such tender foliage as peach resulted from two applications of the sodium oleate soap when used in solutions not exceeding six pounds to fifty gallons of water. But when the sodium soap was used at these strengths on the beetle in the field, the percentage of kill was unsatisfactory. Its efficiency as a contact spray for field use was therefore doubtful. In 1924 various materials were added to the sodium oleate solution in an effort to increase its toxic value without causing injury to the foliage. Among the materials used in combination with the soap was an oleoresin of pyrethrum flowers. This combination gave the most satisfactory results. The oleoresin used was obtained by making an alcoholic extraction of the whole flower heads of *Pyrethrum cinerariaefolium* Trev.

Development of Formula

When oleoresin, emulsified with a small quantity of soap, was first used, it was observed that the beetles fell to the bottom of the cage in a more or less paralyzed condition and remained there for a period ranging from twenty-four to seventy-two hours. At the end of that time the

majority of the beetles recovered and climbed to the top of the wire cage, apparently not in the least affected by the spray. Only a very small percentage was killed. By varying the quantities of sodium oleate and oleoresin in the solution used in the cage and field tests, the following tentative formula was found to give a high percentage of mortality when thoroughly applied:

Oleoresin of pyrethrum flowers	9½ ounces
Oleic acid, U.S.P.	5 pounds
Sodium hydroxide, C. P.	11.2 ounces
Water	50 gallons

Cage Experiments

In the cage experiments, the beetles were subjected to a drenching spray, applied with a quart-size hand sprayer. All of the experiments herein reported were conducted while the beetles were active, this usually occurring during periods of high temperature and low humidity. During such periods the beetles, when confined in cages, invariably cling to the wire netting which forms the top of the cage. In this position they were first sprayed from outside the cage, the spray being forced through the wire, and particular care being taken to cover the ventral side of each beetle. After this was accomplished, the nozzle of the spray was thrust through the door of the cage and the dorsal side of each beetle was sprayed. By the use of this method the beetle was sure to be wetted.

Results of Cage Experiments

Using this formula, under the cage conditions as stated above, the spray gave on an average one hundred per cent kill at the end of a 48-hour period. During the same period ten per cent of the beetles in the check cages died and fifteen per cent in the starvation cages. A soap solution composed of six pounds of sodium oleate to fifty gallons of water sprayed on the beetles, gave a kill of eighty-eight per cent, and a combination of oleoresin, 9½ ounces, and sodium oleate, 9½ ounces, to fifty gallons of water sprayed on the beetles, resulted in a kill averaging forty-four per cent.

Field Experiments

(a) In the field a bucket pump was used in spraying small shrubs and patches of heavily infested smartweed. As soon as the beetles were sprayed they were removed from the plants to cages and given fresh unsprayed smartweed plants. For forty-eight hours they were held under observation, and at the end of that time an examination was made to determine the number dead. Table I gives the data on the nine lots of beetles treated in this manner.

TABLE I. RESULTS OBTAINED FROM SPRAYING JAPANESE BEETLES WITH PYRETHRUM-SOAP SOLUTION ON LOW-GROWING PLANTS.

Lot No.	No. of beetles	No. of dead beetles 48 hours after treatment	Per cent of dead beetles 48 hours after treatment		Foliage sprayed
1	32	31	96.9		Elderberry
2	61	58	95.1		Elderberry
3	160	152	95.0		Smartweed
4	53	45	84.9		Cherry
5	72	67	93.1	Average 95.27	Sassafras
6	122	116	95.1		Smartweed
7	110	110	100.0		Smartweed
8	141	134	95.0		Rose
9	76	74	97.4		Sassafrass
Unsprayed	117	10	8.5	Average 11.0	
Unsprayed	146	20	13.7		
Starvation	134	37	27.6	Average 17.6	
Starvation	145	12	8.3		

The percentage of kill, as shown by Table I, ranges from 84.9 to 100, with an average of 95.2 per cent. The mortality occurring among the unsprayed beetles averaged 11.0 per cent and among those in the starvation cages 17.6.

(b) A power outfit, operating one gun at a pressure of 250 pounds, was used in spraying a number of peach and apple trees heavily infested with the beetle. As the beetles fell or were shaken from the foliage onto canvas, which had previously been placed beneath the tree, they were collected, put in small cages, and treated similarly to the beetles used in the tests described above. Table II gives the results obtained from spraying the solution on fruit trees with a power sprayer.

TABLE II. RESULTS OBTAINED WITH PYRETHRUM-SOAP SOLUTION ON PEACH AND APPLE TREES HEAVILY INFESTED WITH JAPANESE BEETLE

Lot No.	No. of beetles	No. of beetles dead 48 hours after treatment	Per cent of beetles dead 48 hours after treatment	Trees sprayed
1	1,024	964	94.1	Apple
2	750	720	96.0	Peach
3	2,790	2,778	99.6	Peach
4	757	745	98.5	Peach
5	770	763	99.1	Peach
6	429	414	94.2	Apple
7	1,879	1,879	100.0	Peach
8	1,255	1,235	98.4	Peach
9	345	320	92.8	Peach
Check	50	5	10.0	
Starvation	50	8	16.0	
			Av. 98.2	

The number of beetles shown in Table II does not represent the total number on the trees at the time of spraying, for it was impossible to prevent some from flying away during the spraying operation. Therefore, the percentages stated are not accurate, since they do not include all of the beetles. However, many of the beetles which flew away, having received a toxic dose of the spray, died, no doubt, elsewhere. After each test many dead beetles were noticed within a wide area of the sprayed tree.

Results of Field Experiments With Power Sprayer

The results as shown by Table II are taken from nine experiments. The percentage of kill ranged from 92.8 to 100 with an average of 98.2. The percentage of mortality among the beetles in the check cages averaged 6.5 and among the beetles in the starvation cages, 13. Soap was not used alone in these tests, but in earlier field experiments with 6 pounds of sodium soap to 50 gallons of water, the percentage of kill averaged from 40 to 60. The percentages of mortality as shown in the two tables are much higher than will be obtained under regular spraying conditions. The difficulty of applying the spray with complete thoroughness is the limiting factor in obtaining a high percentage of kill when using the solution in the field.

Tests on Foliage

During the season of 1925 such different types of foliage as peach, apple, smartweed, sassafras, rose, and cherry were sprayed twice without any resulting signs of injury.

Summary

On account of the recent discovery of an attrahent for the Japanese beetle, there is urgent need for an effective contact insecticide. The search for a suitable spray has resulted in developing a highly effective solution consisting of sodium oleate and oleoresin of pyrethrum flowers. The best results were obtained with this solution when it was applied under conditions of high temperature and low humidity. Under these conditions the limiting factor is the thoroughness with which the solution is applied. No injury to tender foliage resulted from two applications.

Literature Cited

1. Smith, L. B., and Richmond, E. A. Geraniol, Primary Attractant of the Japanese Beetle. Jour. Econ. Ent. Vol. 18, No. 2, pp. 367–368, 1925.
2. Leach, B. R., and Brinley, F. J. Experiments with Contact Insecticides for the Control of the Japanese Beetle (Popillia japonica). Jour. Econ. Ent. Vol. 15, pp. 302–305, 1922.
3. Kelly, R. W., and Moore, William. Sprays for the Control of the Japanese Beetle. State of New Jersey Circular No. 61.

THE CONTROL OF GRASSHOPPERS BY AIRPLANE DUSTING

By A. A. GRANOVSKY, *University of Wisconsin*

ABSTRACT

This paper contains a brief review of some of the Russian literature with reference to the control of the migratory grasshoppers, *Locusta migratoria* Linn. and *Calliptamus italicus* Linn., by airplane dusting. Several arsenical dusts have been tried experimentally with varied results. Disodium acid arsenite and disodium acid arsenate dusts were used with striking success against hoppers when they were on the wing. This indicates that certain arsenicals can probably be used as contact insecticides.

During the discussion of insect control by the use of airplanes, the writer made a brief remark at the Kansas City Meetings on the control of grasshoppers by airplane dusting in Russia. It was stated that the poison was applied when the migratory hoppers were on the wing during their usual flights in swarms. This remark was based on the following: (1) Several foreign publications little known in this country due to marked differences in languages. (2) Private correspondence with a few entomologists in Urkaine and Russia. (3) Information obtained from Russian entomologists recently visiting this country.

Since this question is of general interest to American entomologists, and since the writer received several inquiries regarding further information on the matter, it will not be amiss to give some of the concrete data obtained in recent experiments conducted by the Russian entomologists. Some of their experiments are certainly unique and may have far-reaching applications in the control of insect pests.

During the war and especially during the revolution, scientific work in Russia suffered serious set backs. The control of injurious insects was neglected and in consequence some of them increased to unbelievable numbers and began to threaten the very existence of human life itself. This fact demanded, and a gradual improvement in economic conditions in the country in general, made it possible to devote a considerable amount of attention to the control of pests, especially the migratory locust, *Locusta migratoria* Linn., which is one of the most important enemies of Russian agriculture.

The first suggestion to use army airplanes to fight insect pests, with special reference to grasshoppers, in Russia, was made by Bogdanov-Katkov in 1921 (See Ref. 1.). Upon his suggestion a commission was appointed to organize a series of experiments and to develop the methods applicable for the purpose of scattering the poisoned bait, spraying, dusting and transporting the materials by airplanes in the infested regions. At the beginning of 1922 several experiments were made near Moscow and in the fields of the Petrovsko-Rasumovsky Agri-

cultural Academy. These experiments consisted of airplane *spraying*. The aim of the experiments was to determine the conditions of flight as to the altitude at which the successful spraying could be done, the amount of the spraying material deposited on the ground, the type of nozzles to use, and the development of signalization between the pilot and the crews at work below. The signal system is of importance in the control of migratory locusts over the vast areas of poorly accessible territory in Eastern Russia.

The airplanes used in these experiments were of Vuazen type, having Salmson motors of 150 horse power with pushing propellers. The second passenger's place was occupied by the "Automax" sprayer of K. Platz Co., which is commonly used in Russia.

To determine the "catch" of the spray on the ground, long rolls of paper were placed on the level ground over which the airplanes passed at the altitude of ½–1; 1½–3; 4–5; 10; 15 meters, etc., until the height of 500 and 600 meters was reached. The planes passed more than one kilometer in straight line during 60 seconds at the speed of 75–80 kilometers per hour. The best results were obtained in using Vermorel nozzles at a pressure of 5 atmospheres and at an altitude of from 4 to 6 meters. Entirely satisfactory results were obtained so far as the fall and spreading of the spray material was concerned at altitudes from 10 to 15 meters. Several arsenical substances were tried, but the Paris green was generally used. This work was in charge of the entomological commission under the leadership of Anutchin at the beginning of the experiments, and, later under that of Boldyrev. (2 and 4.) Intensive experimental tests of airplane spraying were made during the years of 1922–1924, and it may be well to mention that Mr. Boldyrev made remarkable progress in the development of airplane application in the control of insects under Russian conditions.

In the meanwhile Mally (3), working in 1922–23 with grasshoppers in South Africa, found that arsenite of soda could be used as a contact insecticide against the grasshoppers. He dusted the insects with arsenite of soda, using hand dusters and observed that some of the hoppers died within ½ hour after the application of the dust. The majority of hoppers died, however, from 4 to 5 hours after they were dusted.

As soon as Mally's work came to the attention of Russian entomologists, several tests were made by E. E. Sovdarg of Timeriazevskoy Agricultural Academy near Moscow. These experiments proved the general conclusions reached by Mally and produced a few valuable additional observations. It was found that arsenical compounds, especially disodium acid arsenite, $NaHAsO_3$, and disodium acid arsenate,

Na_2HAsO_4 and to a lesser extent white arsenic, arsenite of soda in dust form, and Paris green act as contact insecticides due to their caustic properties. The action of the poison on the nervous system of the insects was also noted.

That arsenical poisons penetrate the chitin of insects was demonstrated by a series of laboratory experiments. This penetration, on account of certain physiological action, caused the death of the dusted insects. Death followed when only the bodies of the insects were dusted, taking special precaution not to dust the antennae and other appendages. In these cases insects did not have an opportunity to lick the appendages within the reach of their mouths, and death evidently did not result from stomach poisoning. When insects were dusted with sodium arsenite on relatively hot and clear days there was sufficient moisture present on their bodies to enable the dust to adhere to them and cause their death. On the other hand, when sodium arsenite spray was used on grasshopper nymphs, some of them died before even water of the spray evaporated from their bodies. This is considered due to the rapid penetration of poison through the chitin of the insects.

Another proof that arsenicals act as contact insecticides is advanced by the fact that the nymphs dusted with sodium arsenite during their molts, if they survived, exhibited marked deformities or were partly paralyzed due to the poison. Some nymphs died before their bodies were sufficiently hardened after molting and before they could take any food. When dissected, no food was found in their digestive tracts, but they showed considerable deformity of legs, wings and in some instances of head and sexual organs, showing that insects died from other cause than that of stomach poisoning. Repeated experiments of dusting the molting nymphs with white arsenic gave similar results. In general, it may be stated that the dusting of nymphs in the molting process gave uneven results as compared with those obtained in the experiments with adult hoppers. An excess of humidity is emphasized as an important factor for the rapid physiological action of arsenical poisons.

A series of experiments in which only antennae were dusted with the sodium arsenite indicate that dusting the antennae alone is sufficient to kill the grasshoppers. Mally assumes that the poison penetrates through the antennal chitin or through the sensory organs and that the insects' death is due to certain action on the nervous system. Boldyrev, however, thinks, and not without reason, that the hoppers in this case lick the poison from their antennae and insects' death is caused by stomach poisoning. From these experiments it may be concluded that insects dusted with the arsenicals may die either from contact or stomach poisoning, or both.

In this connection it might be of interest to mention that during the extensive campaign against grasshoppers in Wisconsin in recent years, the writer had an opportunity to observe many dead hoppers with the ventral side of the posterior part of the thorax and the anterior part of the abdomen burnt and disintegrated. This was ascribed to the corrosive or caustic action of the sodium arsenite used in the bait. Other visible parts of the insects' bodies were evidently unaffected.

The original experiments of Mally and additional ones by Russian workers definitely suggested and led to the possibility of the application of arsenical dusts in the control of grasshoppers. Accordingly, extensive tests have been made in 1924 with *airplane dusting*, near Moscow under the leadership of Boldyrev. These tests gave positive results and attracted a widespread attention of all those interested, throughout the Union of Soviet Republics, in the recent development on the control of insects by airplane dusting.

After a sufficient number of experimental trials, the work in 1925 was transferred to infested regions and breeding grounds of *Locusta migratoria* Linn. for practical control of this pest. Many of the breeding grounds are located along the rivers on poorly drained soil and are almost unaccessible in any other way except by the airplanes. These places are well known through thorough studies made by Dr. V. V. Nikolsky (4), who devoted all of his life to the investigation of the life history and habits of the Asiatic migratory locust and related species in Turkestan and the Caspian regions. The practical control of grasshoppers by airplane dusting with Paris green and disodium acid arsenite has been tried in some of these places, especially in Kuban region and in Ukraine. Entirely satisfactory results have been obtained in Ukraine using the following dust mixtures: (1) Paris green 1 part, flour 11 parts and hydrated lime 10 parts. (2) Disodium acid arsenite 1 part, flour 5 parts, hydrated lime 5 parts and chalk 5 parts. These dusts were applied to vegetation by the airplanes, flying from 8 to 10 meters above the fields and covering strips from 30 to 70 meters wide with each flight. Using this method one airplane dusted from 27 to 40 acres in two minutes, distributing from 2 to 3 liters of dust per acre. Over 4,000 acres of land heavily infested with the Italian locust, *Calliptamus italicus* Linn. were thus dusted with positive results. The most striking instance, however, is the attempted dusting by airplanes of the migratory clouds of *Locusta migratoria* Linn. in the air, using disodium acid arsenite and obtaining positive results beyond expectations. This attempt was based on the experiments described above, which led to

the conclusions that some of the arsenicals can be used as contact insecticides.

REFERENCES

1.—BOGDANOV—KATKOV, N. N. Entomo—Phytopathological Life in South Eastern Russia. Bull. No. 4 of Permanent Bureau of All-Russias Entomo—Phytopath. Congress. Dec. 10, 1921. (In Russian).

2.—BOLDYREV, V. F.—The use of Airplanes in the control of Pests. 1924. (In Russian).

3.—MALLY, C. W.—Arsenite of Soda as a Locust Poison. Jour. of the Dep't of Agri. March, 1923, Pretoria, So. Africa. (In English).

4.—NIKOLSKY, V. V.—Migratory or Asiatic Locust, *Locusta migratoria* L. Monograph, Russian Institute of Economic Agronomy, Vol. *12*, part 2, 332 p. illus. 1925. (In Russian).

Pales Weevil in a New Role. *Hylobius pales* Boh. is a well known feeder upon the stems of young pines. It has appeared in a new role in a recent planting of Scotch pine some 15 years old, at Ballston Spa, N. Y. The trees ranged in size from 1.5 to 5 inches in diameter and were set some 10 to 30 feet apart. Some 25 to 40 per cent of these trees in late June were in a dead or dying condition, in the judgment of Dr. H. H. York, of the State Conservation Commission, and 100 per cent were infested, the lightly infested trees apparently with unimpaired vigor. An examination showed the base of the trees below the surface of the ground, with considerable masses of pitch-infiltered soil, and in cells of this material or working in the cambium of the trees, were found whitish grubs of this species and also some of Pissodes, probably *P. approximatus* Hopk. The estimates of injury in late June were fully confirmed by examinations in late July and in August. At the latter time, larvae, pupae, and adults of Hylobius were found in the burrows or close to the injured cambium; in one instance four weevils occurred around the base of a nearly girdled slightly subnormal appearing tree. The principal offender seems to be the Hylobius, issuing in August and September although numbers of Pissodes were reared in July. Badly affected trees were entirely girdled below the surface, in some instances the injury extending several inches along the principal roots. The infestation appeared to originate from near-by old pines along one side of the planting.

E. P. FELT

The Toxic Values of Certain Fluorides. The insecticidal value of the element fluorine is now well recognized. In referring to the writer's work on fluosilicates, Roark[1] claimed that sodium fluosilicate may cause foliage injury and he advocated the use of the more insoluble fluorides such as calcium, magnesium and strontium fluoride. These were accordingly tried this past summer at Knoxville, Tennessee. Calcium fluoride was entirely ineffective against the Mexican bean beetle (*Epilachna corrupta*). Neither calcium nor magnesium fluoride showed any toxicity towards the Colorado potato beetle (*Leptinotarsa decemlineata*). Against potato beetle larvae strontium fluoride showed a kill of 25 per cent in 48 hours whereas sodium fluosilicate diluted with two parts of hydrated lime killed 95 per cent in 24 hours.

[1]Science, 63:431-432, 1926.

In an effort to explain variable results from a lethal element, it should be born in mind that an element may be in such an insoluble form that it will not kill. A well known example is that of the use of barium sulphate in X-ray work. Cook and McIndoo[2] showed that 90 per cent of the arsenic eaten was voided by the silkworm before death ensued. The highly insoluble lead arsenate is also known to be harmless to blister beetles (*Epicauta* sp.) and grasshoppers. The insoluble fluorides of calcium and magnesium even when in a pulverulent form likewise prove to be ineffective as insecticides.

In his patent No. 1,524,884, Roark claims "an insecticide for dusting or spraying vegetation containing a fluoride whose solubility in water is less than that of barium fluoride." Nevertheless in tests at Knoxville barium fluoride proved to be an efficient insecticide, and showed no foliage injury on either potatoes or beans. This lethal property can hardly be explained, except by the greater solubility of barium fluoride (1–613 at 18°C.).

Although sodium fluosilicate may reduce foliage injury in some cases, burning is reduced to a minimum where hydrated lime is used as a diluent in dusting. It is well known[1] that calcium carbonate forms on the surface of hydrated lime shortly after exposure to the air. Since calcium carbonate is comparatively insoluble, the lime acts for practical purposes, like a neutral diluent. Analagous results were also obtained when neutral gypsum was used instead of the lime. "*Calcium fluosilicate compound*" as well as barium fluosilicate have also been found very safe on several types of foliage.

Roark maintains that commercial sodium fluosilicate contains sodium carbonate and that this alkali carbonate would tend to decompose the fluosilicate with the formation of fluorides. We have been unable to detect any sodium carbonate in several samples examined by us. An analysis submitted by the Virginia-Carolina Chemical Company is as follows:

Sodium fluosilicate	98.55%
Sodium chloride	.60%
Moisture	.10%
Free silica and undetermined	.75%
Sodium carbonate	.00%

The writer has been making quantitative toxicological tests which will be reported in the near future. These tests show that the sodium fluosilicate is about 10 times more effective than sodium fluoride against certain insects when figured on a gram-molecular basis. In view of the foregoing it appears that for insecticidal purposes:

(1) The fluosilicates are more effective than relatively insoluble fluorides.
(2) The fluosilicates kill more rapidly than do the fluorides.
(3) The fluosilicates are readily obtained in commercial quantities whereas the relatively insoluble fluorides are not, that is in a form suitable for dusting.
(4) The fluosilicates are cheaper than the fluorides.

S. MARCOVITCH, *Agricultural Experiment Station, Knoxville, Tenn.*

[1]U. S. Dept. of Agr. Bull. 1147.
[2]Soil Science Vol. 7: 325-446. 1919

COMMON NAMES OF INSECTS APPROVED FOR GENERAL USE BY AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

FIRST SUPPLEMENT TO LIST APPEARING IN VOLUME 18, PAGES 521–545, 1925

The following list of common names was prepared by the Committee on Nomenclature of the American Association of Economic Entomologists in conformity with instructions given by the Association at its last regular meeting. A list of 91 names was submitted to the members of the Association and of these names the following 65 have met with their approval:

KEY TO SYMBOLS

A—Acarina	De—Dermaptera	L—Lepidoptera
An—Anopleura	H—Hemiptera	M—Miscellaneous
C—Coleoptera	Hy—Hymenoptera	O—Orthoptera
D—Diptera	N—Nemopteroids	T—Thysanoptera

INSECTS LISTED BY COMMON NAMES

American grasshopper (O)..... Schistocerca americana Drury
Apple flea weevil (C)..... Orchestes pallicornis Say
Apple redbug (H)..... Lygidea mendax Reut.
Avocado whitefly (H)..... Trialeurodes floridensis Quaint.
Banded cucumber beetle (C)..... Diabrotica balteata Lec.
Banded woolly bear (L)..... Isia isabella S. & A.
Birch skeletonizer (L)..... Bucculatrix canadensisella Chamb.
Black ladybeetle (C)..... Rhizobius ventralis Er.
Camphor scale (H)..... Pseudaonidia duplex Ckll.
Cherry leaf beetle (C)..... Galerucella cavicollis Lec.
Chicken mite (A)..... Dermanyssus gallinae Redi
Chrysanthemum aphid (H)..... Macrosiphoniella sanborni Gill.
Clear-winged grasshopper (O)..... Camnula pellucida Scudd.
Clover root curculio (C)..... Sitona hispidula Fab.
Columbine leaf miner (D)..... Phytomyza aquilegiae Hardy
Corn leaf aphid (H)..... Aphis maidis Fitch
Crab louse (An)..... Phthirius pubis L.
Cranberry weevil (C)..... Anthonomus musculus Say
Eastern lubber grasshopper (O)..... Romalea microptera Beauv.
Eggplant lacebug (H)..... Gargaphia solanii Heid.
Elm cockscomb gall (H)..... Colopha ulmicola Fitch
Elm scurfy scale (H)..... Chionaspis americana Johns.
Ermine moth (L)..... Hyponomeuta malinellus Zell.
European corn borer (L)..... Pyrausta nubilalis Hübn.
European earwig (De)..... Forficula auricularia L.
European pine shoot moth (L)..... Rhyacionia buoliana Schiff.
Fowl tick (A)..... Argas miniatus Koch
Garden flea hopper (H)..... Halticus citri Ashm.

Garden springtail (M).....Sminthurus hortensis Fitch
Green bug (H).....Toxoptera graminum Rond.
Green-striped maple worm (L).....Anisota rubicunda Fab.
Japanese beetle (C).....Popillia japonica Newm.
Lesser bulb fly (D).....Eumerus strigatus Fallén
Lesser peach borer (L).....Sesia pictipes G. & R.
Locust leaf miner (C).....Chalepus dorsalis Thunb.
Long-tailed mealybug (H).....Pseudococcus adonidum L.
Oblique-banded leaf roller (L).....Cacoecia rosaceana Harr.
Orchid fly (Hy).....Eurytoma orchidarum Westw.
Oriental rat flea (M).....Xenopsylla cheopis Rothsch.
Pale western cutworm (L).....Porosagrotis orthogonia Morr.
Pepper weevil (C).....Anthonomus eugenii Cano
Raspberry fruit worm (C).....Byturus unicolor Say
Rat flea (M).....Ceratophyllus fasciatus Bosc.
Red-necked cane borer (C).....Agrilus ruficollis Fab.
Rose aphid (H).....Macrosiphum rosea L.
Rosy apple aphid (H).....Anuraphis roseus Baker
Satin moth (L).....Stilpnotia salicis L.
Sorghum midge (D).....Contarinia sorghicola Coq.
Southern green stink bug (H).....Nezara viridula L.
Spanish fly (C).....Cantharis vesicatoria L.
Squash bug (H).....Anasa tristis DeG.
Sticktight flea (M).....Echidnophaga gallinacea Westw.
Striped horse fly (D).....Tabanus lineola Fab.
Surinam roach (O).....Pycnoscelus surinamensis L.
Sweet potato whitefly (H).....Bemisia inconspicua Quaint.
Turnip weevil (C).....Listroderes obliquus Gyll.
Twice-stabbed ladybeetle (C).....Chilocorus bivulnerus Muls.
Violet aphid (H).....Neotoxoptera violae Perg.
Western tent caterpillar (L).....Malacosoma pluvialis Dyar
White peach scale (H).....Aulacaspis pentagona Targ.
Woolly elm aphid (H).....Eriosoma americanum Riley
Woolly pear aphid (H).....Eriosoma pyricola Baker & Davidson
Yellow woolly bear (L).....Diacrisia virginica Fab.

Insects Listed By Scientific Names

Agrilus ruficollis Fab.....Red-necked cane borer
Anasa tristis DeG.....Squash bug
Anisota rubicunda Fab.....Green-striped maple worm
Anthonomus eugenii Cano.....Pepper weevil
Anthonomus musculus Say.....Cranberry weevil
Anuraphis roseus Baker.....Rosy apple aphid
Aphis maidis Fitch.....Corn leaf aphid
Argas miniatus Koch.....Fowl tick
Aulacaspis pentagona Targ.....White peach scale
Bemisia inconspicua Quaint.....Sweet potato whitefly
Bucculatrix canadensisella Chamb.....Birch skeletonizer
Byturus unicolor Say.....Raspberry fruit worm

Cacoecia rosaceana Harr.....Oblique-banded leaf roller
Camnula pellucida Scudd.....Clear-winged grasshopper
Cantharis vesicatoria L.....Spanish fly
Ceratophyllus fasciatus Bosc.....Rat flea
Chalepus dorsalis Thunb.....Locust leaf miner
Chilocorus bivulnerus Muls.....Twice-stabbed ladybeetle
Chionaspis americana Johns.....Elm scurfy scale
Colopha ulmicola Fitch.....Elm cockscomb gall
Contarinia sorghicola Coq.....Sorghum midge
Dermanyssus gallinae Redi.....Chicken mite
Diabrotica balteata Lec.....Banded cucumber beetle
Diacrisia virginica Fab.....Yellow woolly bear
Echidnophaga gallinacea Westw.....Sticktight flea
Eriosoma americanum Riley.....Woolly elm aphid
Eriosoma pyricola Baker & Davidson.....Woolly pear aphid
Eumerus strigatus Fallén.....Lesser bulb fly
Eurytoma orchidarum Westw.....Orchid fly
Forficula auricularia L.....European earwig
Galerucella cavicollis Lec.....Cherry leaf beetle
Gargaphia solanii Heid.....Eggplant lacebug
Halticus citri Ashm.....Garden flea hopper
Hyponomeuta malinellus Zell.....Ermine moth
Isia isabella S. & A.....Banded woolly bear
Listroderes obliquus Gyll.....Turnip weevil
Lygidea mendax Reut.....Apple redbug
Macrosiphoniella sanborni Gill.....Chrysanthemum aphid
Macrosiphum rosae L.....Rose aphid
Malacosoma pluvialis Dyar.....Western tent caterpillar
Neotoxoptera violae Perg.....Violet aphid
Nezara viridula L.....Southern green stink bug
Orchestes pallicornis Say.....Apple flea weevil
Phthirius pubis L.....Crab louse
Phytomyza aquilegiae Hardy.....Columbine leaf miner
Popillia japonica Newm.....Japanese beetle
Porosagrotis orthogonia Morr.....Pale western cutworm
Pseudaonidea duplex Ckll.....Camphor scale
Pseudococcus aonidum L.....Long-tailed mealybug
Pycnoscelus surinamensis L.....Surinam roach
Pyrausta nubilalis Hbn.....European corn borer
Rhizobius ventralis Er.....Black ladybeetle
Rhyacionia buoliana Schiff.....European pine shoot moth
Romalea microptera Beauv.....Eastern lubber grasshopper
Schistocerca americana Drury.....American grasshopper
Sesia pictipes G. & R.....Lesser peach borer
Sitona hispidula Fab.....Clover root curculio
Sminthurus hortensis Fitch.....Garden springtail
Stilpnotia salicis L.....Satin moth
Tabanus lineola Fab.....Striped horse fly
Toxoptera graminum Rond.....Green bug
Trialeurodes floridensis Quaint.....Avocado whitefly
Xenopsylla cheopis Rothsch.....Oriental rat flea

Scientific Notes

Crepe Myrtle Plant Louse. The Crepe Myrtle (*Lagerstroemia indica*) is perhaps the most widely used ornamental shrub throughout the Gulf States. Its most serious enemy is a small plant louse that at times produces complete defoliation or renders the foliage unsightly by the black sooty mold that grows in its "honey-dew" excretion. During the summer of 1922, practically every Crepe Myrtle in the City of New Orleans, Louisiana, had its foliage rendered a dirty brown to black or else entirely defoliated. This species was at first determined by several specialists as an undescribed species of *Myzocallis* but the writer, after a careful comparison of material, came to the conclusion that the species concerned was no other than *Myzocallis kahawaluakolani*, described by Kirkaldy from Oahn, Honolulu material collected "on *Lagerstroemia indica*, an introduced plant, and also on other shrubs." (See Fullaway for description, Ann. Rept. Haw. Agr. Expt. Station, 1909, p. 43.) Although a careful search has been made for other host plants, the writer has been unable to find this species attacking anything besides the Crepe Myrtle. Its most consistent enemies in the Gulf Coast section are *Olla abdominalis sobrina* Casey, a coccinellid that is easily mistaken for the twice-stabbed lady beetle, and a species of *Chrysopa*. The following distribution notes are given as being of interest to record:—

Hattiesburg, Miss., Aug. 21, 1920—Crepe Myrtles very heavily infested in nursery and on hotel grounds.

Baton Rouge, La., July 27, 1922—Fairly abundant.

Mobile, Ala., Aug. 1, 1922—Heavily infested over city.

Biloxi, Miss., Aug. 6, 1922—Crepe Myrtles over the entire city heavily infested.

Grand Bay, Ala., Aug. 7, 1922—Light infestation. A few Sept. 27, 1922.

New Orleans, La., June 22–Sept. 23, 1922—Extremely heavily infested; by Aug. 15th many trees were in a deplorable condition and only a very few trees in bloom.

H. L. Dozier, *Entomologist, Del. Agr. Expt. Sta., Newark, Del.*

Notes on the recent Outbreak of Toxoptera Graminum. Some of our entomologists whose memory can recall ancient history will remember 1907 as the year when the "green bug," *Toxoptera graminum* Rond., inflicted damage to small grains, estimated roughly and conservatively at $15,000,000. The writer was in the infested region during the entire outbreak, to its anticlimax, and has a very vivid recollection of the manner in which tens of thousands of acres of young grain in Oklahoma and Kansas melted to nothing before the irresistible attack of the billions of this tiny pest. The cold spring of that year, following a warm March, was the green bug's ally, since the species can reproduce at temperatures but little above freezing point, while the predacious and parasitic enemies of the pest require much warmer weather in order to make a successful fight against it.

Portions of the state of Minnesota, a region heretofore supposed to lie too far north for any general increase of the green bug, were the scene of unusual damage during the spring and summer of 1926. So insidious was the first approach that but little attention was paid to the conditions until much of the injury was done. Reports of destruction began to appear in the daily press early in July, and the writer, wishing to compare the present trouble with that of 1907 with which he was so familiar, repaired to the injured area, the center of which was located not far from Willmar, Minnesota, and spent several days in that vicinity.

Judging by appearances the Toxoptera reached the grain fields too late to do

damage to the early sown ones, hence the country presented the unusual phenomenon of ruined fields lying adjacent to normally good ones. The nearly equal stage of maturity of all small grain in mid-July minimizes most of the difference caused by variable sowing dates.

Oats suffered much more than other grains from this attack, probably because of their being sown later than either wheat or barley, and the worst damaged fields looked as if a prairie fire had swept across them, leaving them worthless even for cattle feed.

The counties of Stearns and Pope were near the center of the worst infestation, but I learn from Mr. C. E. Mickel, Assistant Professor of Entomology at the Experiment Farm, St. Paul, who recently completed a careful investigation covering much of the state of Minnesota, that the entire state was infested to a greater or less extent, from the Iowa line to the Canada border. Indeed, it is probable that many of the migrants even invaded Canada, but their numbers were too few or their arrival too late, so far north, to make any noticeable impression on many of the fields. The writer has visited fields in western Iowa that have suffered from the ravages of the green bug, so the presence of the pest seems to have been general throughout the northern section of the grain growing region of the Mississippi valley.

At the time of the writer's visit in July all the mischief had been done and the last generation of aphids had acquired wings and had moved north in search of younger and more palatable food. A few colonies were still to be found on the fresh sprouts that often grow from the older roots, while late sown oats and barley, nurse crops for alfalfa and other forage plants, harbored many winged migrants, recently arrived.

It is only fair to the green bug to remark in passing that the unusually dry summer was an important factor in the amount of injury done by the Toxoptera, the lack of surface moisture checking the rapid growth of the plants and making the attack of the aphids more deadly in its effects.

As was the case in Kansas in 1907, it seems that these aphids rose into the air in Minnesota only when the wind was from the south, so the whole trend of the migration was continually northward.

It has not yet been possible to determine the starting point of the recent outbreak, but without much doubt winter wheat or volunteer grain well to the south of Iowa, given an early start by the unusual warmth of the early spring of the present year, furnished the myriads that moved north and dropped into the grain fields over which the wind bore them.

It seems that the stay of the Toxoptera in the fields of Minnesota was too brief to allow its enemies to increase to the numbers necessary to overtake and subdue it. Coccinellids were present in considerable numbers, but here, as in Kansas, they accomplished but little in the matter of effective control. The small internal hymenopterous parasite, *Aphidius testaceipes* Cress. that made such a complete overthrow of the green bug in Kansas, early in May, 1907, was noticeably absent in Minnesota, only a very few parasitized Toxoptera being observed during the investigation. It is probable that coccinellid and chrysopid larvae destroyed large numbers of the aphids but were unable to cope with their rapid multiplication. By the middle of July an unusual number of at least three species of coccinellid larvae were present in the Minnesota fields.

So many factors are involved in an inimical and destructive increase and migration of *Toxoptera graminum* Rond. that the writer ventures the prediction that the present generation of entomologists may not live to see another outbreak such as those of 1907 and 1926.

C. N. AINSLIE

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1926

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $2.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

One hundred separates or reprints at $1.50 per page or plate. Additional hundreds or less, 4 pages or less, $1.00; 5–8 pages, $1.50; 9–12 pages, $1.75; 13–16 pages, $2.00; 17–24 pages, $3.00; 25–32 pages, $4.00. Covers suitably printed on first page only, 100 copies, or less, $4.50; additional hundreds, or less, $1.75. Plates inserted, $1.75 per hundred, or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $3.00. A discount of 10 per cent and 20 per cent from the above prices will be allowed on orders of 500 and 1000 reprints respectively.

The airplane is pushing to the front as a ready and efficient method of distributing insecticides. The limits have not been reached and the demonstration of the efficiency of an arsenical as a contact insecticide suggests possibilities of poisoning insects while in flight—grasshoppers or even Japanese beetles. It seems quite within possiblities to annihilate millions of swarming insects at slight cost and thus bring dangerous infestations well below the point of serious menace, and at the same time greatly lessen the probabilities of extensive spread by flight, drifting or other agencies.

The symposium on the fundamental value of life history data deserves careful study and in no place is it of more importance than in biological control work. The paper by Mr. Smith suggests great need for systematic biological studies of many parasitic forms in somewhat the same comprehensive manner as a taxonomist works over a group. There are many such contributions to the life history of one or more parasites. The study in this issue of the Hymenopterous parasites of certain Syrphidae helps to clear up one phase of a large problem. We know far too little of the part parasitic insects play in controlling pests or in holding species to a comparatively insignificant role.

No man can control the winds. "The wind bloweth where it listeth" and no man knows "whence it cometh and whither it goeth." It is nearly as true today as when it was first written. This is also true to a large extent of the automobile, except that the place of origin is usually ascertainable while the ultimate destination is generally shrouded in mystery. The movements of individual machines are extremely erratic.

Both winds and automobiles are agents in the dissemination of insects and while the latter are visible and individual, collectively there are practical difficulties in regulating their movements in such a manner as to prevent transportation of insects. The spread of some recently introduced insects is such as to raise questions at times as to whether air currents or automobiles were the important factors. It is recalled that in the early days of gipsy moth infestation there was a most careful examination of automobiles crossing quarantine lines and winds were then regarded as of minor importance. This verdict has been reversed in the supreme court of experience and investigation. Test cases are now pending and are likely to come up in the future in regard to other pests, since method of spread has a vital bearing on insect control.

Reviews

How Insects Live, an Elementary Entomology by WALTER HOUSLEY WELLHOUSE, pages i-xv, 1-435, 333 text illustrations, The Macmillan Co., New York, 1926.

The volume gives an excellent, comprehensive account of the various phases of insect life, there being an introductory chapter on anatomy and physiology, followed by a series of chapters devoted to the orders recognized, the general principles of classification, a list of the orders and the families included under each, a general discussion of the phylum Arthropoda and finally a chapter giving directions for collecting insects and illustrated keys for distinguishing the principal orders and families in both adult and larval stages.

The author has succeeded admirably in presenting the general facts in relation to an extremely large group. There is no glossary. There is no need of one. It is a story largely in the vocabulary of average individuals with a minimum of technical terms, the elucidation of the latter being simple and direct. Entomology Made Easy, would be a fitting subtitle and yet, the volume is scientifically accurate. The selection of a few, well known types for the various orders, permits reasonably full presentations of data without undue condensation. The well selected references open a ready path for those in search of additional information. Many of the figures are reproductions from standard works. The illustrated keys, especially those of the larval stages, must prove of great assistance to the beginner and very likely to those more advanced in entomology. We approve relegating the more technical matter to the end of the volume. It is easily found by those who are in search of it and the plan thus permits starting at once with the main theme—the insects.

We believe the book is a very desirable addition to entomological literature. It is no unimportant function to make scientific information readily available, especially when it is remembered that controversy is due in large measure to misunderstanding —a failure to properly evaluate all the factors. E. P. FELT

Current Notes

Mr. S. Marcovitch, Entomologist, Tennessee Agricultural Experiment Station, is on a leave of absence to pursue graduate work at the University of Minnesota.

Dr. Oscar C. Bartlett, State Entomologist of Arizona, visited Washington, D. C., on June 12, and the Arlington, Mass., Corn borer laboratory on June 15.

Mr. G. S. Walley arrived in Ottawa on July 8 from the Niagara district, where he had spent several weeks collecting insects for the National collection.

Miss Irene D. Dobroscky, a member of the staff of the Boyce Thompson Institute for Plant Research, is continuing graduate work for a doctor's degree in entomology at Cornell University.

Mr. Charles H. Hadley, Director Pennsylvania Bureau of Plant Industry, and Messrs. T. L. Guyton and H. B. Kirk, Entomologists of Harrisburg, Pa., were recent visitors at the Japanese Beetle Laboratory, Riverton, N. J.

Messrs. K. M. King and N. J. Atkinson of the Entomological Branch, Canadian Department of Agriculture, received the degree of master of science at the May Convocation of the University of Saskatchewan.

The Department of Entomology at the Maine Agricultural Experiment Station has recently been reinforced by Mr. J. H. Hawkins, who, as Assistant Entomologist, is working with Mr. C. R. Phipps on economic problems.

According to *Science*, Dr. Harrison G. Dyar, U. S. National Museum, has resumed work in the Museum after several months spent in the West, chiefly at the ranger camp near Belton, Montana.

Mr. D. J. Caffrey returned to Arlington, Mass., on June 17, after spending about ten weeks conducting field experiments and observations in the corn borer infested areas of Michigan, Ohio, Pennsylvania, New York and Ontario.

Mr. Geo. F. Knowlton has been appointed Assistant Entomologist at the Utah Agricultural Experiment Station, in connection with the Beet Leafhopper investigation.

Mr. Charles T. Greene, of the Bureau of Entomology, has returned from a four months' stay in the Canal Zone, where, in cooperation with the Federal Horticultural Board, he has been investigating fruit flies.

Dr. J. McDunnough returned to Ottawa on August 4 from the Rocky Mountain region of British Columbia, where for two months he had been continuing faunal studies and collecting insects for the National Collection.

In June, Mr. A. F. Satterthwait, in charge of the Webster Groves laboratory of the Bureau of Entomology, made a survey of the billbug situation in New Jersey and near-by territory, visiting Washington on June 17.

Mr. M. C. Lane, in charge of the Toppenish laboratory of the Bureau of Entomology, recently made a short trip into southern Idaho, where, accompanied by Mr. F. H. Shirck, he made a survey of wireworm conditions in the Boise Valley.

Dr. Roger C. Smith, Associate Professor of Entomology, and Dr. Ralph L. Parker, Assistant Professor of Entomology, at the Kansas State Agricultural College, have been promoted, respectively, to a professorship and associate professorship in the same institution.

Dr. R. H. Painter, who recently received his doctorate from Ohio State University, has been appointed Assistant Professor of Entomology at the Kansas State Agricultural College. During the summer, Dr. Painter was engaged in entomological work in Spanish Honduras.

According to *Science*, the title of Professor William Morton Wheeler of the Bussey Institution of Harvard University, has been changed from Professor of Economic Entomology to Professor of Entomology, and Dr. Charles T. Brues has been promoted to an associate professorship of economic entomology.

Dr. S. B. Fracker, State Entomologist of Wisconsin, Prof. R. E. Vaughan, of the University of Wisconsin, and Mr. Nudick, Chief of the Bureau of Plant Industry, Maine Department of Agriculture, were visitors in June at the summer laboratory of the Bureau of Entomology at Columbus, Wis.

Dr. J. L. Horsfall has resigned his position as entomologist with the American Cyanamid Company to accept the position of entomologist with the Bayer Company. He will be located at the Boyce Thompson Institute for Plant Research, Yonkers, N. Y., where he will conduct studies with various Bayer preparations.

Mr. W. A. Ross of the Vineland, Ont., laboratory, Entomological Branch, visited Niagara County, N. Y., on June 16, in order to look over orchards infested with the cottony peach scale. Lime-sulphur and soluble sulphur, used by fruit growers in controlling the scale in this district, proved quite useless.

Dr. A. L. Quaintance, Associate Chief, Bureau of Entomology, Dr. T. J. Headlee, State Entomologist of New Jersey, and Mr. C. H. Hadley, Director, Pennsylvania Bureau of Plant Industry, members of the advisory committee on the Japanese Beetle project, met recently at Riverton to discuss matters of policy relating to this project.

Among recent visitors to the Victoria, B. C. laboratory of the Entomological Branch were Mr. and Mrs. Arthur Gibson, July 3 to 5; Dr. Carl J. Drake, of the University of Iowa, July 4 to 7; Dr. L. G. Saunders of the University of Saskatchewan, July 14 to 15, and Dr. E. M. Walker of Toronto University.

Dr. Philip Luginbill, recently of the Columbia, S. C. laboratory of the Bureau of Entomology, has been placed in charge of the new laboratory at Monroe, Michigan, established by the Michigan Agricultural College and the Bureau of Entomology for the study of problems involving the European Corn borer in southeastern Michigan.

Mr. F. W. Poos, formerly in charge of the European Corn Borer Laboratory for the Bureau of Entomology at Sandusky, Ohio, resigned to become entomologist for the Virginia Truck Experiment Station, Norfolk, Va., effective March 20, 1926. Mr. Poos has recently completed the work for the Ph.D. degree at Ohio State University.

Mr. Harold S. Peters, who received the M.Sc. degree from Ohio State University this year, was appointed, effective June 19, 1926, Assistant Entomologist for the Virginia Truck Experiment Station, Norfolk, Va., vice Mr. H. J. Henderson, resigned. Mr. Peters is now stationed at Onley, Va. in connection with the potato tuber worm problem.

Dr. J. M. Swaine, Entomological Branch, accompanied by Dr. I. W. Bailey, Professor of Forestry, Bussey Institution, Harvard University, left Ottawa for Nova Scotia and Cape Breton on August 2, to make a study of the European beech bark louse situation. This insect is reported to be a serious menace to beeches in Nova Scotia.

According to *Experiment Station Record*, Dr. P. M. Gilmer, Associate Professor of Biology and Entomologist at the New Mexico College and Station, has been appointed in charge of an entomological laboratory to be established in southern Kansas for the study of the codling moth, by the U. S. Department of Agriculture in cooperation with the Kansas Station.

Owing to the reorganization of the Southern Field Crop Insect Investigations of the Bureau of Entomology, the project "Sugar Cane and Rice Insects" has been transferred to the Division of Cereal and Forage Insect Investigations, effective July 1, thus adding to the personnel of this Division Messrs. Thos. E. Holloway, Wallace E. Haley, and Jesse W. Ingram.

Mr. K. W. Babcock, of the Arlington Corn Borer Laboratory of the Bureau of Entomology, now engaged in ecological investigations in Europe, reports that the Hungarian Ministry of Agriculture has again revived the "Edict of 1917" compelling all property owners to clean up cornstalks and other susceptible plant material in areas infested by the corn borer.

The following men are temporarily employed at the Japanese Beetle Laboratory, Riverton, N. J.: C. A. Clark, E. E. Atwood, and E. G. Lundberg, Connecticut Agricultural College; E. Rivney, C. A. Crooks, and F. E. Baker, Massachusetts Agricultural College; A. T. Hawkinson, Rutgers University; W. E. Jordan, Cornell University; C. H. McDonnell, Wesleyan University; I. L. Hunt, K. B. Rogers, and H. W. Coward, University of Pennsylvania.

Dr. W. H. Larrimer of the Bureau of Entomology attended a meeting of manufacturers of farm machinery in Chicago on June 2. This meeting, intended to enlist the cooperation of manufacturers in the development of farm machinery to aid in the control of the corn borer, was also attended by Messrs. L. H. Worthley and D. J. Caffrey of the same division.

Mr. C. H. Curran returned to Ottawa on July 8 from a two weeks' collecting trip in the Orillia district, Ont. While at Orillia Mr. Curran also carried out certain work in stored product investigations. He visited Toronto for two days in mid-July in connection with the infestation with lepidopterous larvae of a large shipment of peanuts from Java.

Mr. Arthur Gibson, the Dominion Entomologist, returned to Ottawa from Western Canada on August 10. He reports a very successful trip, during which all the field laboratories in the West were visited. While at Lethbridge, he addressed the Gyro Club on the work of the Branch. The various provincial organizations where entomological work is being carried on were also visited.

Dr. H. H. Knight, of Iowa State College, has been appointed entomologist by the Bureau of Entomology and was assigned to work on collections of Miridae from June 20 until about the end of August. The Bureau is interested in the arrangement and classification of the Miridae in the collections in the Museum, so that identification of insects belonging to this group may be facilitated.

Dr. W. V. Balduf, University of Illinois, is working in the U. S. National Museum during the summer under a special grant, and in this time expects to continue his studies on chalcid flies belonging to the family Eurytomidae. Dr. Balduf has been studying the eurytomids for some time and hopes with the aid of the material in the National Collection to be able to complete certain taxonomic papers on this group.

As reported by Mr. L. H. Patch of the Bureau of Entomology, the first observed pupation of the European corn borer in the field in Ohio occurred June 5, five days later than in 1925. In western New York Mr. H. N. Bartley recorded the first pupation on June 15, eleven days later than in 1925. In New England, the early pupation, adult emergence, and deposition of eggs were about two weeks later than normal.

Messrs. C. H. Hadley, T. J. Headlee, and William Rudolfs started September 10 on an automobile trip through the regions infested by the European corn borer. They first visited Long Island, then crossed the Sound into Connecticut, where they were joined by Mr. L. H. Worthley, and for the day by Mr. R. A. Vickery, and Dr. W. E. Britton. The others expected to spend about two days around eastern Massachusetts, then motor westward to see the corn borer areas in eastern and western New York and attend the meetings in Ohio, Michigan and Ontario, September 23–24.

Dr. J. M. Aldrich, Associate Curator of the Division of Insects, U. S. National Museum, returned to Washington early in June, after a two months' collecting trip in Guatemala. Dr. Aldrich was able to collect a considerable number of interesting flies and rear a small number of fruit flies. In addition, he cooperated with the Guatemalan Department of Agriculture in a conference on grasshoppers, and had expert advice on the dipterous parasites of the forms of grasshoppers which are so abundant in Guatemala and neighboring countries.

The following men were temporarily appointed as field assistants in the Bureau of Entomology, and assigned to the laboratories indicated: Dr. D. M. De Long, H. L. Weatherby and O. E. Gahm, Mexican bean beetle investigations, Columbus, Ohio; Herman Beerman, truck crop insect investigations, Philadelphia, Pa.; W. J. Douglass, Mexican bean beetle investigations, Estancia, N. M.; A. C. Davis, truck crop insect investigations, Alhambra, Calif.; George W. Still, L. E. Briggs, M. F. Sawyer, European Corn borer investigations, Arlington, Mass.; George B. Kunkel, Hessian Fly investigations, Carlisle, Pa.; A. I. Balzar, and R. A. Blanchard, European Corn borer work, Monroe, Mich.

According to *Science*, an insect belonging to the Diptera, that spends its whole life in salt sea water, is the strange find reported to the Royal Society by Mr. F. W. Edwards and Dr. P. A. Buxton of the British Museum. Dr. Buxton, who recently returned from a voyage to Samoa, found the insect associated with related forms whose larval or infant stages are spent in the water, but whose adult life is lived in the normal aerial surroundings of most insects. This is said to be the first recorded case of an insect going through its whole life cycle in sea water.

Mr. L. S. McLaine was absent from Ottawa July 21–30, visiting Southern Ontario in connection with inspection work and the Oriental peach moth and European corn borer work. He attended meetings of the Canadian Florists and Gardeners Association at London and discussed the regulations governing the importation of plants. On July 30, Mr. McLaine attended a conference on European corn borer parasite work, at Chatham, with Dr. L. O. Howard, Chief of the United States Bureau of Entomology, Mr. W. R. Walton and Mr. D. J. Caffrey, in charge of corn borer investigations in Massachusetts.

Mr. W. S. Fisher, of the U. S. National Museum, returned on June 30 from a trip to Boston, New York, and Philadelphia, where he examined types of buprestid beetles of the genus Agrilus in the collections of the Boston Society of Natural History, the Museum of Comparative Zoology, the American Museum of Natural History, the Academy of Natural Sciences, Philadelphia, and the collection of Dr. Fall. Mr. Fisher has nearly completed his manuscript for a revision of this interesting and important group of buprestid beetles, and has been able to examine practically all of the types of the species of the genus Agrilus.

Mr. Ed. Foster, collaborator of the Federal Horticultural Board, recently sent additional specimens of the introduced West Indian termite, *Cryptotermes brevis* Walker, to Dr. T. E. Snyder of the Bureau of Entomology. This termite not only damaged a trunk in St. Anna's Asylum in New Orleans, La., but also furniture and woodwork of the building. The trunk has been disposed of, and arrangements are being made to fumigate the building with hydrocyanic-acid gas, which is effective only against nonsubterranean "powder-post" termites. Elsewhere in the United States *Cryptotermes brevis* occurs only in southern Florida, and there always indoors in buildings. It has never been found out of doors in this country. Since this insect was introduced into South Africa, the same has been found true of it there.

Mr. L. B. Parker left Riverton, N. J., on June 7 for the Pacific Coast, to board ship at San Francisco for the Orient. With the exception of a possible brief stop in Japan, to confer with T. R. Gardner, formerly stationed at the Riverton Laboratory, he went direct to Calcutta. The objective point of Mr. Parker's journey is Shillong, capitol of the province of Assam, in the northeastern part of India. From Calcutta to Shillong the distance is some five hundred miles. For the present, headquarters will be located at this place, where Mr. Parker will join C. P. Clausen, who has already spent five years in the Far East doing similar work, and together they will search for parasites of the Japanese beetle, to be introduced into the United States.

A survey of field conditions in New England, made in April and May by Messrs. D. W. Jones, R. C. Ellis, W. G. Bradley, B. E. Hodgson, and H. J. Cronin, showed that the careful practice there of clean-up methods in cornfields and weed areas had reduced the volume of plant material infested by the corn borer to such an extent that it has been difficult to obtain sufficient material for use in research. This condition has been brought about largely through the action of the Massachusetts clean-up law, compelling the feeding, plowing under, or burning of infested material, plus the educational effect of destructive outbreaks in the past. The low ebb of infestation in the past spring, together with the delayed seasonal development of the corn borer in May and June, indicates a continued reduction of corn borer infestation during the coming season.

The third National Shade Tree Conference was held in the vicinity of Philadelphia, August 2 and 3, and about 60 tree specialists were present. Entomologists attending were: Dr. E. P. Felt, Albany, N. Y.; C. H. Hadley, F. M. Trimble, and Dr. T. L. Guyton, Harrisburg, Pa.; Mr. A. F. Burgess, Melrose Highlands, Mass.; Mr. W. O. Hollister, Kent, Ohio; Mr. H. L. Frost, Arlington, Mass.; Mr. John B. Gill, Thomasville, Ga.; Dr. W. E. Britton, New Haven, Conn. At Riverton the visitors conferred with Messrs. Loren B. Smith, J. L. King, H. W. Allen, E. A. Richmond, and E. R. Van Leeuwen of the Japanese Beetle Laboratory, and in Philadelphia they saw J. G. Sanders and P. T. Barnes. The new officers of the conference are: Chairman, Dr. E. P. Felt, Albany, N. Y.; Secretary, W. O. Filley, New Haven, Conn.

Apicultural Notes

During the month of August, Mr. W. J. Nolan, of the Bee Culture Laboratory of the Bureau of Entomology, attended beekeepers' meetings in Vermont, New Hampshire, and Maine.

During August Mr. E. L. Sechrist, of the Bee Culture Laboratory of the Bureau of Entomology, attended a series of beekeeping meetings held in Massachusetts, Connecticut, and New York State.

Prof. George H. Rea will succeed to the position of Extension Apiculturist at Cornell made vacant by the resignation of Professor Willson, this appointment becoming effective about October 1, 1926.

Miss Winifred S. Hull resigned her position as Assistant Scientific Aid at the Bee Culture Laboratory, of the Bureau of Entomology, on September 1. Miss Hull plans to resume her studies at Vassar College.

Recent visitors at the Bee Culture Laboratory included Prof. James Ritter, teacher of beekeeping in St. Louis College, Honolulu, Hawaii; Mr. L. E. Dill, a state extension worker from West Virginia; and Mr. J. M. Barr, one of the leading beekeepers of Wisconsin.

Prof. R. B. Willson, after four years' valuable service as Extension Apiculturist to the New York beekeepers, left August 1, 1926, to take charge of the honey sales for the Herschel Jones Marketing Service, Inc., 97 Warren St., New York City.

Mr. C. E. Burnside resigned his position as Junior Biologist at the Bee Culture Laboratory, of the Bureau of Entomology, on September 1. He will take up research work on bee diseases at the University of Michigan. During this past summer he has been devoting his attention to fungous diseases of honeybees. Professor L. M. Bertholf of Western Maryland College, and Carlton E. Burnside of the University of Michigan, have accepted temporary appointments as junior biologists in the Bureau of Entomology. Both are continuing investigations previously begun, Professor Bertholf on the light responses of the honeybee, and Mr. Burnside on the fungous diseases of the honeybee.

On July 1, Mr. Virgil N. Argo resigned his temporary appointment as Field Assistant of the Bee Culture Laboratory of the Bureau of Entomology. During his appointment he conducted investigations on *Braula coeca* at New Windsor, Md. in an endeavor to work out obscure points of its life history, more especially in the fore part of the active season. Mr. Argo expects to continue graduate work at Cornell University this year.

Dr. H. Prell of Germany, so well known through his work on forest insects, is at present in this country studying apicultural methods, as well as the work and progress of forest insects in this country. During July he spent some time at the Bee Culture Laboratory of the Bureau of Entomology. Doctor Prell, last year, identified a species of Amoeba found quite commonly encysted in the Malpighian tubules of honeybees in colonies infected with *Nosema apis*. He has named this species *Vahlkampfia* (*Malpighamoeba*) *mellifica*.

Mr. James I. Hambleton, of the Bee Culture Laboratory of the Bureau of Entomology, attended the Ontario-Michigan Beekeepers' Meeting at Port Huron, Mich., on August 12–13, and the Dadant Memorial Meeting at Platteville, Wis., on August

17–20. The latter meeting was held in honor of the Dadant family who have been so prominent in beekeeping circles in this country during the last half century. Following these meetings Mr. Hambleton made a trip to the intermountain region for the purpose of choosing a location for the new bee-culture field station made possible by the last agricultural appropriation act.

Notes on Medical Entomology

Mr. G. H. Hammond of the Hemmingford, Que. laboratory, Entomological Branch recently submitted the largest collection of mosquitoes yet received from Quebec for the Canadian National collection.

Mr. Eric Hearle, of the Indian Head, Sask. laboratory, Entomological Branch, visited Regina on June 29 to confer with officials of the Provincial Live Stock Branch and the Saskatchewan Live Stock Pool regarding major insect pests of cattle.

Mr. C. R. Twinn, Entomological Branch, visited Montreal the latter part of July and early August, in connection with the control of the European household mosquito, *Culex pipiens*, which breeds in immense numbers in a sewage-contaminated swamp extending for over a mile below Notre Dame de Grace. Labor, equipment and oil were supplied for control work, by the Canadian National Railway and the Notre Dame de Grace Citizens Association. Messrs. W. St. G. Ryan, N. Cameron and N. Beaudoin, of the Montreal Inspection Office, have assisted in supervising the control operations.

Prof. R. A. Cooley, State Entomologist of Montana, visited Naushon Island, near Woods Hole, Massachusetts, on July 12 to 15 at the invitation of Dr. Wolbach, of the Harvard Medical School, to confer with Dr. F. Larrousse, from Dr. Brumpt's laboratory in Paris. Dr. Larrousse is stationed on Naushon Island for the purpose of colonizing the tick parasite, *Ixodiphagus caucurtei* Buysson, on the American dog tick, *Dermacentor variabilis* Say, which is very abundant and troublesome on that island. The purposes of the conference were to observe Dr. Larrousse's methods and to obtain a supply of the parasites. The Board of Entomology of Montana hopes to be able to colonize this parasite on the tick, *Dermacentor andersoni* Stiles, which transmits Rocky Mountain spotted fever.

Notes on Horticultural Inspection

The apple sucker scouting work in New Brunswick and Nova Scotia was completed on July 6. No new territory was found infested.

Scouting for the Mexican bean beetle in south-central and southwestern Ontario has so far failed to reveal any evidence of the pest.

Mr. John P. Young has been transferred from Nogales, Arizona, to Seattle, Washington, to assist with the inspection work of the Federal Horticultural Board at that port.

Mr. Ira Collins, who has been stationed at Seattle, Washington, resigned his position as plant quarantine inspector with the Federal Horticultural Board, August 31.

Messrs. George F. Smith and Ipark Whiton have been appointed junior plant quarantine inspectors with the Federal Horticultural Board with headquarters at New York.

Mr. Carl H. Spiegelberg, junior plant quarantine inspector at New York City, has resigned his position with the Board to resume his studies at the University of Maryland.

Mr. Harvey A. Horton, formerly in charge of the work of the Federal Horticultural Board at St. Louis, who resigned February 28, 1925, has been reinstated and is stationed at Seattle, Washington.

Mr. Martin J. Forsell, who resigned his position with the Federal Horticultural Board several months ago, has been reinstated as junior plant quarantine inspector with headquarters at Seattle, Washington.

The Arizona News Letter for July, in its summary of the work of the road inspection stations, furnished the following facts. Number of cars inspected—12,171. Number of cars carrying contraband—10,644.

Mr. M. J. Kerr, who was in charge of the work of the Federal Horticultural Board at Mobile, Ala., has been transferred to New Orleans, La. The work at Mobile will be handled by state inspectors collaborating with the Board.

Mr. L. M. Scott of the plant quarantine inspection service, Federal Horticultural Board, recently visited the eastern Canadian border ports for the purpose of conferring with the Bureau of Animal Industry inspectors stationed at the various ports.

Garlic is apparently selected as a food plant by several discriminating insects. Two weevils, *Brachycereus albidentatus* Gyll. and *B. undatus* Fab., have recently been taken in bulbs of this plant arriving from Southern Europe at New York City. The Narcissus Bulb Fly and the Lesser Bulb Fly have also been found in garlic.

The U. S. Department of Agriculture has recently issued Quarantine No. 63 pertaining to the White Pine Blister Rust. The Quarantine is effective on and after October 1, 1926, and supersedes Quarantines No. 26 and No. 54. By this Order every state in the United States and the District of Columbia are placed under quarantine.

The inspection of orchards in the Niagara district of Ontario for evidence of the presence of the Oriental peach moth is proceeding slowly, the lightness of the infestation in most orchards necessitating very careful examination of the trees. A general scouting of the district will be made.

To assist in enforcing European corn borer quarantine regulations in Ontario, Canada, warning posters have been placed on all roads leading from quarantined districts and in the principal towns and cities in the affected area. Copies of the revised regulations have also been sent to the agents of transportation companies.

Mr. T. A. Arnold, an inspector of the Federal Horticultural Board, recently intercepted a package of cotton seed in the mail at El Paso, Texas, addressed to Mr. C. J. King, Agronomist and Superintendent, U. S. Field Station, Sacaton, Ariz. An examination of the seed resulted in finding twenty-two living larvae and one living pupa of the pink Bollworm. The country of origin could not be determined.

The eighth annual meeting of the Western Plant Quarantine Board was held at Olympia, Washington, June 9, 10 and 11. The program covered a number of plant

quarantine subjects and included reports on quarantine conditions in the various states represented and addresses by officials of the Post Office Department, transportation companies and the U. S. Department of Agriculture.

The State of Arizona has issued Quarantine Order No. 22, effective on and after August 15, 1926, relating to the Thurberia cotton boll weevil. The Quarantine prohibits the movement of all parts of the cotton plant, including all forms of cotton lint, cotton seed, cotton seed hulls, and cotton seed cake and meal, as well as the Thurberia plant, from the infested territory in the counties of Pima, Santa Cruz and Pinal, to other portions of the State of Arizona until such products have been properly sterilized, and then only under special authorization by the state entomologist of Arizona.

Pacific Slope Notes

Mr. E. M. Ehrhorn, for the last 17 years Chief of the Division of Plant Inspection of the Board of Agriculture and Forestry of Honolulu, Hawaii, retired from active duties on August 1, and is now engaged as consulting entomologist of several corporations for termite control. His new address is P. O. Box 2456, Honolulu, Hawaii.

On September 17, a number of state, Federal, county and private entomologists met at the laboratory of the Bureau of Entomology in Alhambra, California, and formed the Entomological Club of Southern California. The object is "to promote the science of entomology, and foster fellowship among entomologists." Any one interested in entomology is eligible to membership. It is planned to make the club as informal as possible. Meetings will be held quarterly. The following officers were elected: President, H. J. Quayle; vice-president, R. S. Woglum; secretary-treasurer, Roy E. Campbell. Those present who became charter members were: H. M. Armitage, W. C. Beckley, Roy E. Campbell, Renand Candron, Harold Compere, Clifford Dodds, Charles Duggan, J. C. Elmore, S. H. Essig, C. K. Fisher, L. R. Gardner, F. C. Greer, Hugh Knight, A. O. Larson, William Langdon, J. R. La Follette, L. E. Myers, D. D. Penny, H. J. Quayle, I. L. Ressler, H. J. Ryan, H. S. Smith, A. F. Swain, V. I. Safro, P. H. Timberlake, V. E. Williams, R. W. Woglum, and P. F. Wright.

Apple and Thorn Skeletonizer in Pennsylvania. The apple and thorn skeletonizer (*Hemerophila pariana* Clerck) has made its appearance in destructive numbers in northeastern Pennsylvania. This is the first known wide distribution of this European pest in the State. At present the area of heavy infestation is in two counties, where apple trees are heavily infested and the foliage badly skeletonized. No damage was evident in orchards where sprays had been made for the control of the Codling Moth.

F. L. GUYTON

A Leaf-hopper Becomes Predaceous. On the night of Aug. 6, 1926 my room on the sixth floor of a down-town hotel in St. Louis, Mo., was invaded by a great number of leaf-hoppers determined by W. L. McAtee as *Euscelis exitiosus* Uhler. I had gone to sleep with the lights turned on and was awakened by the bites of these insects. I turned off the lights and their attacks ceased. The bites caused a mild itching and a small round red discoloration of the skin around each puncture which persisted for several days.

C. R. CROSBY